

TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

23 00 00 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

23 05 13 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

23 05 53 IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

23 07 00 HVAC INSULATION

23 09 00 INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

**BAS/DDC CONTROLS
TO BE OFOI**

23 21 13 HVAC PIPING

23 31 00 HVAC DUCTS AND CASINGS

23 33 00 AIR DUCT ACCESSORIES

23 37 00 AIR OUTLETS AND INLETS

23 40 00 HVAC AIR CLEANING DEVICES

23 72 23 PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

23 81 43 AIR SOURCE HEAT PUMPS

23 82 00 TERMINAL HEAT TRANSFER EQUIPMENT

DIVISION 26 - ELECTRICAL

26 00 00 ELECTRICAL BASIC REQUIREMENTS

26 05 09 EQUIPMENT WIRING

26 05 19 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

26 05 33 RACEWAYS

26 05 34 BOXES

26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS

26 27 26 WIRING DEVICES

26 28 00 OVERCURRENT PROTECTIVE DEVICES

26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Work included in 23 00 00, HVAC Basic Requirements applies to Division 23, HVAC work to provide materials, labor, tools, permits, incidentals, and other services to provide and make ready for Owner's use of heating, ventilating and air conditioning systems for proposed project.
- B. Contract Documents include, but are not limited to, Specifications including Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Drawings, Addenda, Owner/Architect Agreement, and Owner/Contractor Agreement. Confirm requirements before commencement of work.
- C. Definitions:
 - 1. Provide: To furnish and install, complete and ready for intended use.
 - 2. Furnish: Supply and deliver to project site, ready for unpacking, assembly and installation.
 - 3. Install: Includes unloading, unpacking, assembling, erecting, installation, applying, finishing, protecting, cleaning and similar operations at project site as required to complete items of work provided.
 - 4. Approved or Approved Equivalent: To possess the same performance qualities and characteristics and fulfill the utilitarian function without any decrease in quality, durability or longevity. For equipment/products defined by the Contractor as "equivalent", substitution requests must be submitted to Engineer for consideration, in accordance with Division 01, General Requirements, and approved by the Engineer prior to submitting bids for substituted items.
 - 5. Authority Having Jurisdiction (AHJ): Indicates reviewing authorities, including local fire marshal, Owner's insurance underwriter, Owner's Authorized Representative, and other reviewing entity whose approval is required to obtain systems acceptance.

1.2 RELATED SECTIONS

- A. Contents of Section applies to Division 23, HVAC Contract Documents.
- B. Related Work:
 - 1. Additional conditions apply to this Division including, but not limited to:
 - a. Specifications including Division 00, Procurement and Contracting Requirements and Division 01, General Requirements.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

- b. Drawings
- c. Addenda
- d. Owner/Architect Agreement
- e. Owner/Contractor Agreement
- f. Codes, Standards, Public Ordinances and Permits

1.3 REFERENCES AND STANDARDS

- A. References and Standards per Division 01, General Requirements, individual Division 23, HVAC Sections and those listed in this Section.
- B. Codes to include latest adopted editions, including current amendments, supplements and local jurisdiction requirements in effect as of the date of the Contract Documents, of/from:
 - 1. State of Oregon:
 - a. OAR - Oregon Administrative Rules
 - b. 2021 OESC - Oregon Electrical Specialty Code
 - c. 2019 OFC - Oregon Fire Code
 - d. 2019 OMSC - Oregon Mechanical Specialty Code
 - e. 2021 OPSC - Oregon Plumbing Specialty Code
 - f. 2019 OSSC - Oregon Structural Specialty Code
 - g. 2021 OEESC - Oregon Energy Efficiency Specialty Code
 - h. 2011 Oregon Elevator Specialty Code
- C. Reference standards and guidelines include but are not limited to the latest adopted editions from:
 - 1. ABA - Architectural Barriers Act
 - 2. ABMA - American Bearing Manufacturers Association
 - 3. ADA - Americans with Disabilities Act
 - 4. AHRI - Air-Conditioning Heating & Refrigeration Institute
 - 5. AMCA - Air Movement and Control Association

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

6. ANSI - American National Standards Institute
7. ASCE - American Society of Civil Engineers
8. ASHRAE - American Society of Heating, Refrigeration and Air-Conditioning Engineers
9. ASHRAE Guideline 0, The Commissioning Process
10. ASME - American Society of Mechanical Engineers
11. ASPE - American Society of Plumbing Engineers
12. ASSE - American Society of Sanitary Engineering
13. ASTM - ASTM International
14. AWWA - American Water Works Association
15. CFR - Code of Federal Regulations
16. CGA - Compressed Gas Association
17. CISPI - Cast Iron Soil Pipe Institute
18. EPA - Environmental Protection Agency
19. ETL - Electrical Testing Laboratories
20. FM - FM Global
21. GAMA - Gas Appliance Manufacturers Association
22. HI - Hydraulic Institute Standards
23. IAPMO - International Association of Plumbing & Mechanical Officials
24. IFGC - International Fuel Gas Code
25. ISO - International Organization for Standardization
26. MSS - Manufacturers Standardization Society
27. NEC - National Electric Code
28. NEMA - National Electrical Manufactures Association
29. NFPA - National Fire Protection Association
30. NFGC - National Fuel Gas Code

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

31. NRCA - National Roofing Contractors Association
32. NSF - National Sanitation Foundation
33. OSHA - Occupational Safety and Health Administration
34. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association, Inc.
35. TEMA - Tubular Exchanger Manufactures Association
36. TIMA - Thermal Insulation Manufactures Association
37. UL - Underwriters Laboratories, Inc.

D. See Division 23, HVAC individual Sections for additional references.

1.4 SUBMITTALS

- A. See Division 01, General Requirements for Submittal Procedures as well as specific individual Division 23, HVAC Sections.
- B. Provide drawings in format and software release equal to the design documents. Drawings to be the same sheet size and scale as the Contract Documents.
- C. In addition:
 1. "No Exception Taken" constitutes that review is for general conformance with the design concept expressed in the Contract Documents for the limited purpose of checking for conformance with information given. Any action is subject to the requirements of the Contract Documents. Contractor is responsible for the dimensions and quantity and will confirm and correlate at the job site, fabrication processes and techniques of construction, coordination of the work with that of all other trades, and the satisfactory performance of the work.
 2. Provide product submittals and shop drawings in electronic format only. Electronic format must be posted to ftp site and be native/searchable PDF format. Scanned copies are not acceptable. For electronic format, provide one file per division containing one bookmarked PDF file with each bookmark corresponding to each Specification Section. Arrange bookmarks in ascending order of Specification Section number. Individual submittals sent piecemeal in a per Specification Section method will be returned without review or comment. All transmissions/submissions to be submitted to Architect. At Contractor's option, four separate submittals may be provided, consisting of long lead items, underground/site work, building work, and building automation system. Deviations will be returned without review.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

3. Product Data: Provide Manufacturer's descriptive literature for products specified in Division 23, HVAC Sections.
4. Identify/mark each submittal in detail. Note what differences, if any, exist between the submitted item and the specified item. Failure to identify the differences will be considered cause for disapproval. If differences are not identified and/or not discovered during the submittal review process, Contractor remains responsible for providing equipment and materials that meet the Specifications and Drawings.
 - a. Label submittal to match numbering/references as shown in Contract Documents. Highlight and label applicable information to individual equipment or cross out/remove extraneous data not applicable to submitted model. Clearly note options and accessories to be provided, including field installed items. Highlight connections by/to other trades.
 - b. Include technical data, installation instructions and dimensioned drawings for products, fixtures, equipment and devices installed, furnished or provided. Reference individual Division 23, HVAC Specification Sections for specific items required in product data submittal outside of these requirements.
 - c. Provide pump curves, operation characteristics, capacities, ambient noise criteria, etc. for equipment.
 - d. For vibration isolation of equipment, list make and model selected with operating load and deflection.
 - e. See Division 23, HVAC individual Sections for additional submittal requirements outside of these requirements.
5. Maximum of two reviews of submittal package. Arrange for additional reviews and/or early review of long-lead items; Bear costs of these additional reviews at Engineer's hourly rates. Incomplete submittal packages/submittals will be returned to contractor without review.
6. Resubmission Requirements: Make corrections or changes in submittals as required, and in consideration of Engineer's comments. Identify Engineer's comments and provide an individual response to each of the Engineer's comments. Cloud changes in the submittals and further identify changes which are in response to Engineer's comments.
7. Structural/Seismic: Provide weights, dimensions, mounting requirements and like information required for mounting, seismic bracing, and support. Indicate manufacturer's installation and support requirements to meet Section 23 05 48, Vibration and Seismic Controls for HVAC Equipment. Provide engineered

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

seismic drawings and equipment seismic certification. Equipment Importance Factor as specified in Division 01 and in Structural documents.

8. Trade Coordination: Include physical characteristics, electrical characteristics, device layout plans, wiring diagrams, and connections as required by Division 23, HVAC Coordination Documents. For equipment with electrical connections, furnish copy of approved submittal for inclusion in Division 26, Electrical submittals.
9. Make provisions for openings in building for admittance of equipment prior to start of construction or ordering of equipment.
10. Substitutions and Variation from Basis of Design:
 - a. The Basis of Design designated product establishes the qualities and characteristics for the evaluation of any comparable products by other listed acceptable manufacturers if included in this Specification or included in an approved Substitution Request as judged by the Design Professional.
 - b. If substitutions and/or equivalent equipment/products are being proposed, it is the responsibility of parties proposing the substitute and/or equivalent equipment to verify and compare the characteristics and requirements of that furnished to that specified and/or shown. If greater capacity and/or more materials and/or more labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then provide compensation for additional charges required for the proper rough-in, circuitry and connections for the equipment being furnished. No additional charges above the Base Bid, including resulting charges for work performed under other Divisions, will be allowed for such revisions. Coordinate with the requirements of "Submittals". For any product marked "or approved equivalent", a substitution request must be submitted to Engineer for approval prior to bid.
11. Shop Drawings: Provide coordinated shop drawings which include physical characteristics of all systems, equipment, ductwork and piping layout plans, and control wiring diagrams. Reference individual Division 23, HVAC Specification Sections for additional requirements for shop drawings outside of these requirements.
 - a. Provide Shop Drawings indicating access panel locations for items that require Code or maintenance access, size and elevation for approval prior to installation.
12. Samples: Provide samples when requested by individual Sections.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

13. Resubmission Requirements:
 - a. Make any corrections or change in submittals when required. Provide submittals as specified. The Engineer will not be required to edit and/or interpret the Contractor's submittals. Indicate changes for the resubmittal in a cover letter with reference to page(s) changed and reference response to comment. Cloud changes in the submittals.
 - (1) Resubmit for review until review indicates no exception taken or make "corrections as noted".
 - (2) When submitting drawings for Engineer's re-review, clearly indicate changes on drawings and "cloud" any revisions. Submit a list describing each change.
14. Operation and Maintenance Manuals, Owner's Instructions:
 - a. Submit, at one time, electronic files (native/searchable PDF format) of manufacturer's operation and maintenance instruction manuals and parts lists for equipment or items requiring servicing. Submit data when work is substantially complete and in same order format as submittals. Include name and location of source parts and service for each piece of equipment.
 - (1) Include copy of approved submittal data along with submittal review letters received from Engineer. Data to clearly indicate installed equipment model numbers. Delete or cross out data pertaining to other equipment not specific to this project.
 - (2) Include copy of manufacturer's standard Operations and Maintenance for equipment. At front of each tab, provide routine maintenance documentation for scheduled equipment. Include manufacturer's recommended maintenance schedule and highlight maintenance required to maintain warranty. Furnish list of routine maintenance parts, including part numbers, sizes, quantities, relevant to each piece of equipment: belts, motors, lubricants, and filters.
 - (3) Include Warranty per Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Sections.
 - (4) Include product certificates of warranties and guarantees.
 - (5) Include copy of complete parts list for equipment. Include available exploded views of assemblies and sub assemblies.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

- (6) Include copy of startup and test reports specific to each piece of equipment.
 - (7) Include copy of final air and water systems balancing log along with pump, fan and distribution system operating data.
 - (8) Include commissioning reports.
 - (9) Include copy of valve charts/schedules.
 - (10) Engineer will return incomplete documentation without review. Engineer will provide one set of review comments in Submittal Review format. Contractor must arrange for additional reviews; Contractor to bear costs for additional reviews at Engineer's hourly rates.
 - b. Thoroughly instruct Owner in proper operation of equipment and systems. Where noted in individual Sections, training will include classroom instruction with applicable training aids and systems demonstrations. Field instruction per Section 23 00 00, HVAC Basic Requirements Article titled "Demonstration".
 - c. Copies of certificates of code authority inspections, acceptance, code required acceptance tests, and other special guarantees, certificates of warranties, specified elsewhere or indicated on Drawings.
15. Record Drawings:
 - a. Maintain at site at least one set of drawings for recording "As-constructed" conditions. Indicate on drawings changes to original documents by referencing revision document, and include buried elements, location of cleanouts, and location of concealed mechanical items. Include items changed by field orders, supplemental instructions, and constructed conditions.
 - b. Record Drawings are to include equipment and fixture/connection schedules, control dampers, fire smoke dampers, fire dampers, valves, bottom of pipe, duct and equipment elevations and dimensioned locations for all distribution systems (hydronic and air). Invert elevations and dimensioned locations for underground systems below grade to 5-foot outside building that accurately reflect "as constructed or installed" for project.
 - c. At completion of project, input changes to original project CAD Drawings and make one set of black-line drawings created from CAD Files in version/release equal to contract drawings. Submit CAD Files

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

and drawings upon substantial completion.

- d. At completion of project, show changes and deviations from the Drawings in red on one set of black-line drawings. Include written Addendums, RFIs, and change order items. Make changes to Drawings in a neat, clean, and legible manner.
- e. See Division 23, HVAC individual Sections for additional items to include in record drawings.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Work and materials installed to conform with all local, State and Federal codes, and other applicable laws and regulations. Where code requirements are at variance with Contract Documents, meet code requirements as a minimum requirement and include costs necessary to meet these in Contract. Machinery and equipment are to comply with OSHA requirements, as currently revised and interpreted for equipment manufacturer requirements. Install equipment provided per manufacturer recommendations.
- B. Whenever this Specification calls for material, workmanship, arrangement or construction of higher quality and/or capacity than that required by governing codes, higher quality and/or capacity take precedence.
- C. Drawings are intended to be diagrammatic and reflect the Basis of Design manufacturer's equipment. They are not intended to show every item in its exact dimensions, or details of equipment or proposed systems layout. Verify actual dimensions of systems (i.e., piping) and equipment proposed to assure that systems and equipment will fit in available space. Contractor is responsible for design and construction costs incurred for equipment other than Basis of Design, including, but not limited to, architectural, structural, electrical, HVAC, fire sprinkler, and plumbing systems.
- D. Manufacturer's Instructions: Follow manufacturers' written instructions. If in conflict with Contract Documents, obtain clarification. Notify Engineer/Architect, in writing, before starting work.
- E. Items shown on Drawings are not necessarily included in Specifications or vice versa. Confirm requirements in all Contract Documents.
- F. Provide products that are UL listed.
- G. Piping and duct insulation products to contain less than 0.1 percent by weight PBDE in all insulating materials.
- H. ASME Compliance: ASME listed water heaters and boilers with an input of 200,000 BTUH and higher, hot water storage tanks which exceed 120 gallons, and hot water expansion tanks which are connected to ASME rated equipment or required by code or

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

local jurisdiction.

- I. Provide safety controls required by National Boiler Code (ASME CSD 1) for boilers and water heaters with an input of 400,000 BTUH and higher.

1.6 WARRANTY

- A. Provide written warranty covering the work for a period of one year from date of Substantial Completion in accordance with Division 00, Contracting and Procurement Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Sections under this Division can require additional and/or extended warranties that apply beyond basic warranty under Division 01, General Requirements and the General Conditions. Confirm requirements in all Contract Documents.

1.7 COORDINATION DOCUMENTS

- A. Prior to construction, coordinate installation and location of HVAC equipment, ductwork, grilles, diffusers, piping, equipment, fire sprinklers, plumbing, cable trays, lights, and electrical services with architectural and structural requirements, and other trades (including ceiling suspension, and tile systems), and provide maintenance access requirements. Coordinate with submitted architectural systems (i.e. roofing, ceiling, finishes) and structural systems as submitted, including footings and foundation. Identify zone of influence from footings and ensure systems are not routed within the zone of influence.
- B. Advise Architect in event a conflict occurs in location or connection of equipment. Bear costs resulting from failure to properly coordinate installation or failure to advise Architect of conflict.
- C. Submit final Coordination Drawings with changes as Record Drawings at completion of project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Articles, fixtures, and equipment of a kind to be standard product of one manufacturer, including but not limited to pumps, fans, valves, control devices, air handlers, vibration isolation devices, etc.

2.2 STANDARDS OF MATERIALS AND WORKMANSHIP

- A. Base contract upon furnishing materials as specified. Materials, equipment, and fixtures used for construction are to be new, latest products as listed in manufacturer's printed catalog data and are to be UL or ETL listed and labeled or be approved by State, County,

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

and City authorities prior to procurement and installation.

- B. Names and manufacturer's names denote character and quality of equipment desired and are not to be construed as limiting competition.
- C. Hazardous Materials:
 - 1. Comply with local, State of Oregon, and Federal regulations relating to hazardous materials.
 - 2. Comply with Division 00, Procurement and Contracting Requirements and Division 01, General Requirements for this project relating to hazardous materials.
 - 3. Do not use any materials containing a hazardous substance. If hazardous materials are encountered, do not disturb; immediately notify Owner and Architect. Hazardous materials will be removed by Owner under separate contract.

2.3 ACCESS PANELS

- A. See Division 01, General Requirements and Division 08, Openings for products and installation requirements.
- B. Confirm Access Panel requirements in Division 01, General Requirements, Division 08, Openings and individual Division 23, HVAC Sections. In absence of specific requirements in Division 01, General Requirements, comply with the following:
 - 1. Provide flush mounting access panels for service of systems and individual components requiring maintenance or inspection. Where access panels are located in fire-rated assemblies of building, rate access panels accordingly.
 - a. Ceiling access panels to be minimum 24-inch by 24-inch required and approved size.
 - b. Wall access panels to be minimum of 12-inch by 12-inch required and approved size.
 - c. Provide screwdriver operated catch.
 - d. Manufacturers and Models:
 - (1) Drywall: Karp KDW.
 - (2) Plaster: Karp DSC-214PL.
 - (3) Masonry: Karp DSC-214M.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

- (4) 2 hour rated: Karp KPF-350FR.
- (5) Manufacturers: Milcor, Elmdor, Acudor or approved equivalent.

PART 3 - EXECUTION

3.1 ACCESSIBILITY AND INSTALLATION

- A. Confirm Accessibility and Installation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Install equipment having components requiring access (i.e., drain pans, drains, control operators, valves, motors and vibration isolation devices) so that they may be serviced, reset, replaced or recalibrated by service people with normal service tools and equipment. Do not install equipment in obvious passageways, doorways, scuttles or crawlspaces which would impede or block intended usage.
- C. Install equipment and products complete as directed by manufacturer's installation instructions including all appurtenances recommended in manufacturer's installation instructions, at no additional charge to Owner. Obtain installation instructions from manufacturer prior to rough-in of equipment and examine instructions thoroughly. When requirements of installation instructions conflict with Contract Documents, request clarification from Architect and Engineer prior to proceeding with installation. This includes proper installation methods, sequencing and coordination with other trades and disciplines.
- D. Earthwork:
 - 1. Confirm Earthwork requirements in Contract Documents. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 - a. Perform excavation, dewatering, shoring, bedding, and backfill required for installation of work in this Division in accordance with related earthwork Sections. Contact utilities and locate existing utilities prior to excavation. Repair any work damaged during excavation or backfilling.
 - b. Excavation: Do not excavate under footings, foundation bases, or retaining walls.
 - c. Provide protection of underground systems. Review the project Geotechnical Report for references to corrosive or deleterious soils which will reduce the performance or service life of underground systems materials.
- E. Firestopping:

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

1. Confirm Firestopping requirements in Division 07, Thermal and Moisture Protection. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 - a. Coordinate location and protection level of fire and/or smoke rated walls, ceilings, and floors. When these assemblies are penetrated, seal around piping, ductwork and equipment with approved firestopping material. Install firestopping material complete as directed by manufacturer's installation instructions. Meet requirements of ASTM E814, Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

F. Pipe Installation:

1. Provide installation of piping systems coordinated to account for expansion and contraction of piping materials and building, as well as anticipated settlement or shrinkage of building. Install work to prevent damage to piping, equipment, and building and its contents. Provide piping offsets, loops, seismic flexible joints, expansion joints, sleeves, anchors or other means to control pipe movement and minimize forces on piping. Verify anticipated settlement and/or shrinkage of building with Project Structural Engineer. Verify construction phasing, type of building construction products and rating for coordinating installation of piping systems.
2. Include provisions for servicing and removal of equipment without dismantling piping.

G. Plenums:

1. Plenums: Materials within plenums shall be noncombustible or shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723. Immediately notify Architect/Engineer of any discrepancy.

- H. Provide miscellaneous supports/metals required for installation of equipment, piping, and ductwork.

3.2 SEISMIC CONTROL

- A. Confirm Seismic Control requirements in Division 01, General Requirements, Structural documents, Section 23 0548, Vibration and Seismic Controls for HVAC Equipment, and individual Division 23 HVAC Sections.

B. General:

1. Earthquake resistant designs for HVAC (Division 23) equipment and distribution, i.e. motors, ductwork, piping, equipment, etc. to conform to regulations of jurisdiction having authority.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

2. Restraints which are used to prevent disruption of function of piece of equipment because of application of horizontal force to be such that forces are carried to frame of structure in such a way that frame will not be deflected when apparatus is attached to a mounting base and equipment pad, or to structure in normal way, utilizing attachments provided. Secure equipment and distribution systems to withstand a force in direction equal to value defined by jurisdiction having authority.
 3. Provide stamped Shop Drawings from licensed Structural Engineer of seismic bracing and seismic movement assemblies for piping equipment and water heaters. Submit Shop Drawings along with equipment submittals.
 4. Provide stamped Shop Drawings from licensed Structural Engineer of seismic flexible joints for piping and crossing building expansion or seismic joints. Submit Shop Drawings along with seismic bracing details.
- C. Piping and Ductwork:
1. Per "Seismic Restraints Manual Guidelines for Mechanical Systems" latest edition published by SMACNA or local requirements.
- D. Provide means to prohibit excessive motion of mechanical equipment during earthquake.

3.3 REVIEW AND OBSERVATION

- A. Confirm Review and Observation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Notify Architect and Engineer, in writing, at following stages of construction so that they may, at their option, visit site for review and construction observation:
1. Underground system installation prior to backfilling.
 2. Prior to covering walls.
 3. Prior to ceiling cover/installation.
 4. After major equipment is installed.
 5. When main systems, or portions of, are being tested and ready for inspection by AHJ.
- C. Final Punch:
1. Prior to requesting a final punch visit from the Engineer, request from Engineer the Mechanical Precloseout Checklist, complete the checklist confirming completion of systems' installation, and return to Engineer. Request a final punch

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

visit from the Engineer, upon Engineer's acceptance that the mechanical systems are ready for final punch.

2. Costs incurred by additional trips required due to incomplete systems will be the responsibility of the Contractor.

3.4 CONTINUITY OF SERVICE

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 1. During remodeling or addition to existing structures, while existing structure is occupied, current services to remain intact until new construction, facilities or equipment is installed.
 2. Prior to changing over to new service, verify that every item is thoroughly prepared. Install new piping and ductwork, and wiring to point of connection. Where existing systems are being utilized, clean existing distribution systems (ductwork, piping, fans, air handlers) prior to connecting new ductwork or piping.
 3. Coordinate transfer time to new service with Owner. If required, perform transfer during off peak hours. Once changeover is started, pursue to its completion to keep interference to a minimum.
 - a. If overtime is necessary, there will be no allowance made by Owner for extra expense for such overtime or shift work.
 4. Organize work to minimize duration of power interruption.

3.5 CUTTING AND PATCHING

- A. Confirm Cutting and Patching requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 1. Proposed floor cutting/core drilling/sleeve locations to be approved by Project Structural Engineer. Submit proposed locations to Architect/Project Structural Engineer. Where slabs are of post tension construction, perform x-ray scan of proposed penetration locations and submit scan results including proposed penetration locations to Project Structural Engineer/Architect for approval. Where slabs are of waffle type construction, show column cap extent and cell locations relative to proposed penetration(s).
 2. Cutting, patching and repairing for work specified in this Division including plastering, masonry work, concrete work, carpentry work, and painting included

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

under this Section will be performed by skilled craftspeople of each respective trade in conformance with appropriate Division of Work.

3. Additional openings required in building construction to be made by drilling or cutting. Use of jack hammer is specifically prohibited. Patch openings in and through concrete and masonry with grout.
4. Restore new or existing work that is cut and/or damaged to original condition. Patch and repair specifically where existing items have been removed. This includes repairing and painting walls, ceilings, etc. where existing conduit and devices are removed as part of this project. Where alterations disturb lawns, paving, and walks, surfaces to be repaired, refinished and left in condition matching existing prior to commencement of work.
5. Additional work required by lack of proper coordination will be provided at no additional cost to the Owner.

3.6 EQUIPMENT SELECTION AND SERVICEABILITY

- A. Replace or reposition equipment which is too large or located incorrectly to permit servicing, at no additional cost to Owner.
- B. Maintain design intent where equipment other than as shown as Basis of Design in Contract Documents is provided. Where equipment requires ductwork or piping arrangement, controls/control diagrams, or sequencing different from that indicated in Contract Documents, provide at no additional cost to Owner.

3.7 DELIVERY, STORAGE AND HANDLING

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 1. Handle materials delivered to project site with care to avoid damage. Store materials on site inside building or protected from weather, dirt and construction dust. Insulation and lining that becomes wet from improper storage and handling to be replaced before installation. Products and/or materials that become damaged due to water, dirt, and/or dust as a result of improper storage to be replaced before installation.
 2. Protect equipment and pipe to avoid damage. Close pipe openings with caps or plugs. Keep motors and bearings in watertight and dustproof covers during entire course of installation.
 3. Protect bright finished shafts, bearing housings and similar items until in service.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

3.8 DEMONSTRATION

- A. Confirm Demonstration requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Upon completion of work and adjustment of equipment and test systems, demonstrate to Owner's Authorized Representative, Architect and Engineer that equipment furnished and installed or connected under provisions of these Specifications functions in manner required. Provide field instruction to Owner's Maintenance Staff as specified in Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- C. Manufacturer's Field Services: Furnish services of a qualified person at time approved by Owner, to instruct maintenance personnel, correct defects or deficiencies, and demonstrate to satisfaction of Owner that entire system is operating in satisfactory manner and complies with requirements of other trades that may be required to complete work. Complete instruction and demonstration prior to final job site observations.

3.9 CLEANING

- A. Confirm Cleaning requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Upon completion of installation, thoroughly clean exposed portions of equipment, removing temporary labels and traces of foreign substances. Throughout work, remove construction debris and surplus materials accumulated during work.

3.10 START UP

- A. Start up equipment, in accordance with manufacturer's start-up instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
 - 1. Do not place equipment in sustained operation prior to initial balancing of HVAC systems.

3.11 PAINTING

- A. Confirm Painting requirements in Division 01, General Requirements and Division 09, Finishes. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 - 1. Ferrous Metal: After completion of work, thoroughly clean and paint exposed supports constructed of ferrous metal surfaces in mechanical rooms, i.e., hangers, hanger rods, equipment stands, with one coat of black asphalt varnish for exterior

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

or black enamel for interior, suitable for hot surfaces.

2. After acceptance by Authority Having Jurisdiction (AHJ), In a mechanical room, on roof or other exposed areas, machinery and equipment not painted with enamel to receive two coats of primer and one coat of rustproof enamel, colors as selected by Architect.
3. See individual equipment Specifications for other painting.
4. Structural Steel: Repair damage to structural steel finishes or finishes of other materials damaged by cutting, welding or patching to match original.
5. Piping and Ductwork: Clean, primer coat and paint exposed piping and ductwork on roof or at other exterior locations with two coats paint suitable for metallic surfaces and exterior exposures. Color selected by Architect.
6. Covers: Covers such as manholes, cleanouts and the like will be furnished with finishes which resist corrosion and rust.

3.12 ACCESS PANELS

- A. Confirm Access Panel requirements in Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 1. Coordinate locations/sizes of access panels with Architect prior to work.

3.13 DEMOLITION

- A. Confirm requirements in Division 01, General Requirements and Division 02, Existing Conditions. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 1. Scope:
 - a. It is the intent of these documents to provide necessary information and adjustments to the HVAC system required to meet code, and accommodate installation of new work.
 - b. Coordinate with Owner so that work can be scheduled not to interrupt operations, normal activities, building access or access to different areas.
 - c. Existing Conditions: Determine exact location of existing utilities and equipment before commencing work, compensate Owner for damages caused by failure to exactly locate and preserve utilities. Replace damaged items with new material to match existing. Promptly notify Owner if utilities are found which are not shown on Drawings.

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

2. Equipment: Unless otherwise directed, equipment, fixtures, or fittings being removed as part of demolition process are Owner's property. Remove other items not scheduled to be reused or relocated from job site as directed by Owner.
3. Unless specifically indicated on Drawings, remove exposed, unused ductwork and piping to behind finished surfaces (floor, walls, ceilings, etc.). Cap and patch surfaces to match surrounding finish.
4. Unless specifically indicated on Drawings, remove unused equipment, fixtures, fittings, rough-ins, and connectors. Removal is to be to a point behind finished surfaces (floors, walls, and ceilings).

3.14 ACCEPTANCE

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
 1. System cannot be considered for acceptance until work is completed and demonstrated to Architect that installation is in strict compliance with Specifications, Drawings and manufacturer's installation instructions, particularly in reference to following:
 - a. Testing and Balancing Reports
 - b. Cleaning
 - c. Operation and Maintenance Manuals
 - d. Training of Operating Personnel
 - e. Record Drawings
 - f. Warranty and Guaranty Certificates
 - g. Start-up/Test Document
 - h. Commissioning Reports

3.15 FIELD QUALITY CONTROL

- A. Confirm Field Quality Control requirements in Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Tests:

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

1. Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Reference individual Specification Sections for required tests. Document tests and include in Operation and Maintenance Manuals.
2. During site evaluations by Architect or Engineer, provide appropriate personnel with tools to remove and replace trims, covers, and devices so that proper evaluation of installation can be performed.

3.16 ELECTRICAL INTERLOCKS

- A. Where equipment motors are to be electrically interlocked with other equipment for simultaneous operation, utilize equipment wiring diagrams to coordinate with electrical systems so that proper wiring of equipment involved is affected.

3.17 TEMPORARY HEATING, COOLING AND HUMIDITY CONTROL

- A. Provide temporary heating, cooling, controls, humidification and dehumidification as required to facilitate the construction of the project. Size and select temporary system based on the requirements of the various trades during construction. This includes, but is not limited to, drywall, case work, wood flooring and wood finishes that are subject to warping. Size and install system to prevent mold growth. Coordinate the location of the temporary system. The house system can be used. Develop a procedure for how the house system will be used including a sketch depicting the house system, how filtration will be used to prevent construction debris from entering the system and how often the filters will be changed, how the ductwork will be cleaned after use to ensure a clean system is turned over to the Owner and how the units are sized. Submit this procedure to the Mechanical Engineer for review. Follow National Air Duct Cleaners Association (NADCA) duct cleaning procedures and guidelines. Warranties for the house system, if new, to commence when the Owner moves in if house system is used as the means to maintain the climate within the building during construction. Include this warranty requirement in the original bid or proposal amount. Coordinate and provide any temporary power, controls, ductwork, piping, plumbing anchorage, miscellaneous steel and structural supports required to support the temporary system. Installation of the system to comply with all applicable codes and be acceptable to the Authority Having Jurisdiction (AHJ).

END OF SECTION

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Starters
 - 2. Shaft Grounding
 - 3. Motors

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. NEMA Premium Efficiency
 - 2. Energy Policy Act (EPACT), latest applicable version(s) for minimum motor efficiencies.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Electrical components and materials to be UL and ETL listed/labeled as suitable for location and use.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 2 - PRODUCTS

2.1 STARTERS

A. Manufacturers

1. Cerus
2. Eaton Electrical
3. General Electric
4. Siemens
5. Schneider Electric/Square D

B. Single Phase Motors:

1. Manual across-the-line starting switch having toggle-operated switch pilot running light and built-in thermal overload device with heating element rated not more than 115 percent motor full load current indicated on name plate of motor to be protected. Surface mount starters. Provide NEMA-1 enclosure.
2. Overload relays to be melting alloy type with a replaceable control circuit module. Thermal units to be interchangeable. Starter to be non operative if thermal unit is removed.
3. Single-phase motors with automatic controls. Provide motor-rated relay with coils rated for control voltage.

C. Starters up to Size 8 to be suitable for the addition of a minimum of three external auxiliary contacts (normally open or normally closed). Contactor, coils, and relays to perform the control functions of the associated equipment and control sequence.

D. Three Phase Motors up to and Including 15 HP:

1. Provide enclosed type magnetic across-the-line starter with thermal overload and undervoltage protection.
2. Operator: "Start-Stop" pushbutton, except where automatic control is indicated on Drawings or specified. Then provide "Hand-Off-Auto" selector switch.
3. Starters for 3-phase motors to have overload protection in each of the three legs, with external manual reset.
4. Unless indicated on Drawings or in Specifications, furnish motor starters with a neon pilot light. Neon lights are required for exhaust fan switches.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

5. Equip starters with integral transformer and coil for control circuit. Coordinate coil voltage with control voltage.

2.2 SHAFT GROUNDING

A. Manufacturers

1. Shaft Grounding Inc.
2. Aegis SGR Bearing Protection Ring
3. Or approved equivalent.

B. Variable Speed Motor Shaft Grounding: Shaft grounding ring; solid ring type.

C. Provide shaft grounding assembly on motors controlled by variable frequency drive. Shaft grounding device to be in the form of brush that resides on the motor shaft. Brush assembly shall be capable of tolerating misalignment and maintaining rotating contact throughout the motors life.

D. Material: Material used in the grounding assembly shall be stable material commonly used within industry that is not believed to constitute a hazardous material under Occupational Safety & Health Administration (OSHA) regulations.

E. Brushes: Specifically developed carbon compounds of sustained performance with wear life expectancy of 3 years minimum.

F. Seals: Sealed type to keep contaminants from entering the shaft grounding system in wet or severe environment applications.

2.3 MOTORS

A. Manufacturers:

1. Lincoln Motor
2. Century Electric Motors (formerly A.O. Smith Electrical Products)
3. Baldor Electric
4. General Electric
5. Toshiba
6. Exception: Motors integral to equipment efficiency listing (EER, COP, etc.) per listing agency.

B. Construction:

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

1. Open drip-proof type except where specifically noted otherwise.
 2. Design for continuous operation in 40 degrees C environment.
 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 4. Built-in thermal overload protection or externally protected with separate overload with low-voltage release or lock-out. Quick trip device on hermetically sealed motors.
 5. Service Factor: 1.15 for poly-phase motors except 1.25 for motors associated with shaft pressurization system fans and 1.35 for single phase motors.
 6. Efficiency: Provide NEMA Premium Efficiency motors.
 7. Motors used in conjunction with variable speed drives: Variable torque type matched for the full operating range of the variable frequency drive. As a minimum, motors to have Class F insulation, winding insulation rated for 1000 Volts and insulated bearings to prevent high frequency ground path. Loads not-to-exceed 80 percent of nameplate rating
- C. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- D. Wiring Terminations:
1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Coordinate conductor sizes with Division 26, Electrical. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 2. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.
- E. Single Phase Power, Split Phase Motors:
1. Starting Torque: Less than 150 percent of full load torque.
 2. Starting Current: Up to seven times full load current.
 3. Breakdown Torque: Approximately 200 percent of full load torque.
 4. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
 5. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

- F. Single Phase Power, Permanent-Split Capacitor Motors:
1. Starting Torque: Exceeding one fourth of full load torque.
 2. Starting Current: Up to six times full load current.
 3. Multiple Speed: Through tapped windings.
 4. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.
- G. Single Phase Power, Capacitor Start Motors:
1. Starting Torque: Three times full load torque.
 2. Starting Current: Less than five times full load current.
 3. Pull-up Torque: Up to 350 percent of full load torque.
 4. Breakdown Torque: Approximately 250 percent of full load torque.
 5. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
 6. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
 7. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.
- H. Three Phase Power, Squirrel Cage Motors:
1. Starting Torque: Between 1 and 1-1/2 times full load torque.
 2. Starting Current: Six times full load current.
 3. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
 4. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
 5. Insulation System: NEMA Class B or better. Use class F insulation when motors are controlled by a VFD.
 6. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

7. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
 8. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
 9. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
 10. Sound Power Levels: To NEMA MG 1.
 11. Weatherproof Epoxy Treated Motors: Epoxy coat windings with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
 12. Nominal Efficiency: Meet or exceed NEMA Premium Efficiency rating when tested in accordance with IEEE 112.
 13. Nominal Power Factor: Minimum at full load and rated voltage when tested in accordance with IEEE 112.
- I. Electronically Commutated Motors:
1. Brushless DC type motor specifically designed for intended application.
 2. Permanently lubricated motor with heavy duty ball bearing type to match intended application load.
 3. Operation Range: 20 percent to 100 percent of full speed (80 percent turndown).
 4. Motor Efficiency: Minimum 85 percent efficient at all speeds.
 5. Pre-wired to specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Coordinate location of disconnect and starter or motor controller. Combination starter/disconnects may be used in lieu of separate items.
- B. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

- C. Provide inverter ready motors per NEMA MG1-30 for variable speed drive or soft-start starter use. Provide shaft grounding for motors over 2 HP serving variable speed drives. Provide shaft grounding and insulated bearings on motors 25 HP and larger serving variable speed drives. Shielded cable required for power wiring from variable speed drive to motor connection.
- D. Unless otherwise indicated, motors 1-HP and larger to meet/exceed NEMA Premium Efficiency and latest EPACT.
- E. Exception: Motors less than 250 watts, for intermittent service, motors furnished with equipment manufacturer's standard package equipment need not conform to these specifications.
- F. Single phase motors for air compressors and pumps: Capacitor start type.
- G. Disconnects: Provided by Division 26, Electrical unless specified otherwise.
- H. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

3.2 STARTER INSTALLATION

- A. Install starters in accordance with manufacturer's instructions.
- B. Coordinate disconnect requirements and location with Division 26, Electrical if not integral to starter. If starter is installed out of line of sight of motor, provide additional disconnect at motor per code.
- C. Provide NEMA housing appropriate to installation location.
- D. Provide supports and install securely, in neat and workmanlike manner, as specified in NECA 1.
- E. Meet mounting height and accessible location requirements per local code.
- F. Provide fuses for fusible switches.
- G. Select and install overload heater elements in motor starters to match installed motor characteristics.
- H. Single Phase 120 Volt Starter: If not furnished as single packaged controller/disconnect, provide contactors, relays, wiring and devices necessary to match sequence of operation for equipment.

3.3 SHAFT GROUNDING INSTALLATION

- A. Shaft grounding assembly installation not to affect the motor manufacturer warranty. Where the severe environment conditions require application of the shaft grounding types

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

that are screwed into the motor shaft, the installation of the shaft grounding system performed either by the motor manufacturer or by the motor manufacturer authorized facility.

- B. Bond the brush to the closest ground point using code sized green insulated stranded copper conductor per manufacturer instructions.
- C. Test and verify the performance of the assembly to ensure that under no conditions the shaft exceeds 3 volts.
- D. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- E. Check line voltage and phase and ensure agreement with nameplate.
- F. Verify motor rotation.

3.4 MOTOR INSTALLATION

- A. Electrical Service: Power wiring from source to motor termination under Division 26, Electrical.
- B. Install in accordance with manufacturer's instructions. Coordinate with starter or variable speed controller with control sequence to provide necessary starter accessories.
- C. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- D. Check line voltage and phase and ensure agreement with nameplate.
- E. Verify motor rotation.
- F. Field Quality Control:
 - 1. Prepare for acceptance tests as follows:
 - a. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
 - b. Test interlocks and control features for proper operation.
 - c. Verify that current in each phase is within nameplate rating.
 - 2. Testing: Perform the following field quality-control testing:
 - a. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.
 - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

3. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - a. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with requirements.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - c. Verify bearing lubrication.
 - d. Verify proper motor rotation.
 - e. Test Reports: Prepare a written report to record the following test procedures used:
 - (1) Test results that comply with requirements.
 - (2) Test results that do not comply with requirements and corrective action taken to achieve compliance.
- G. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.
- H. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

This page intentionally left blank

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Hangers and Supports for HVAC Piping, Ductwork and Equipment
2. Wall and Floor Sleeves
3. Building Attachments
4. Flashing
5. Miscellaneous Metal and Materials

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:

1. ASCE 7-16, Minimum Design Loads for Buildings and Other Structures.
2. Terminology: As defined in MSS SP-90 "Guidelines on Terminology for Pipe Hangers and Supports".
3. Install ductwork and piping per SMACNA's requirements.
4. Hanger spacing installation and attachment to meet all manufacturer's requirements and MSS SP-58.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1. Welding:
 - a. Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications".
2. Welding for Hangers:
 - a. Qualify procedures and personnel according to AWS D9.1, Sheet Metal Welding Code for duct joint and seam welding.
3. Engineering Responsibility:
 - a. Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, duct support equipment hangers/supports, support from floor structure, roof structure or from structure above, and seismic restraint by a qualified Structural Professional Engineer.
 - (1) Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.
4. Manufacturers regularly engaged in the manufacture of bolted metal framing support systems, whose products have been in satisfactory use in similar service for not less than 10 years.
5. Support systems to be supplied by a single manufacturer.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 PERFORMANCE REQUIREMENTS

- A. Provide pipe, ductwork and equipment hangers and supports in accordance with the following:
 1. When supports, anchorages, and seismic restraints for equipment, and supports, anchorages, and seismic restraints for conduit, piping, and ductwork are not shown on the Drawings, the contractor is responsible for their design.
 2. Connections to structural framing not to introduce twisting, torsion, or lateral bending in the framing members. Provide supplementary steel as required.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- B. Engineered Support Systems:
 - 1. Support frames such as pipe racks or stanchions for piping, ductwork, and equipment which provide support from below.
 - 2. Equipment, ductwork and piping support frame anchorage to supporting slab or structure.
- C. Provide channel support systems, for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- D. Provide heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- E. Provide seismic restraint hangers and supports for piping, ductwork and equipment. See Section 23 05 48, Vibration and Seismic Controls for HVAC Equipment.
- F. Obtain approval from AHJ for seismic restraint hanger and support system to be installed for piping and equipment. See Section 23 05 48, Vibration and Seismic Controls for HVAC Equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Hangers and Supports for HVAC Piping, Ductwork and Equipment:
 - 1. Anvil International
 - 2. B-Line Systems, Incorporated
 - 3. Erico Company, Incorporated
 - 4. Nelson-Olsen Incorporated
 - 5. Rilco Manufacturing Company, Incorporated
 - 6. Snappitz Thermal Pipe Shield Manufacturing
 - 7. Unistrut Corporation
- B. Wall and Floor Sleeves:
 - 1. Thunderline Corporation "Link Seal".
 - 2. Or approved equivalent.
- C. Building Attachments:
 - 1. Anchor-It

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

2. Gunnebo Fastening Corporation
3. Hilti Corporation
4. ITW Ramset/Red Head
5. Masterset Fastening Systems, Incorporated

2.2 HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- A. Hanger Rods: Hanger rods continuously threaded or threaded ends only in concealed spaces and threaded ends only in exposed spaces; finish electro-galvanized or cadmium-plated in concealed spaces and prime painted in exposed spaces; sizes per MSS.
- B. Hanger Rod Couplings: Anvil Figure 136, B-Line Figure B3220, or approved equivalent; malleable iron rod coupling with elongated center sight gap for visual inspection; to have same finish as hanger rods.
- C. Channel Hanging System:
 1. Framing members No. 12 gauge formed steel channels, 1-5/8-inch square, conforming to ASTM A1011 Grade 33, one side of channel to have a continuous slot within turned lips; framing nut with grooves and spring 1/2-inch size, conforming to ASTM 675 GR60; screws conforming to ASTM A307; fittings conforming to ASTM A575; parts enamel painted or electro-galvanized.
 2. Concrete Inserts: Malleable iron body, hot dipped galvanized finish. Lateral adjustment. MSS Type 18.
- D. Continuous Concrete Insert: Steel construction, minimum 12 gauge. Electro-galvanized finish. Pipe clamps and insert nuts to match.
- E. Pipe Hangers:
 1. Pipe Rings for Hanger Rods:
 - a. Pipe Sizes 2-inches and Smaller: Adjustable swivel ring hanger, UL listed. Erico 100 or 101, Anvil Figures 69 or 104, or approved equivalent.
 - b. Pipe Sizes 2-1/2-inches and Larger: Clevis type hangers with adjustable nuts on rod, UL listed. Anvil figure 260, Erico 400, or approved equivalent.
 - c. Pipe hangers to have same finish as hanger rods.
- F. Pipe Saddles and Shields:

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1. Factory fabricated saddles or shields under piping hangers and supports for insulated piping.
 2. Size saddles and shields for exact fit to mate with pipe insulation. 1/2 round, 18 gauge, minimum 12-inches in length (4-inch pipe and larger to be three times longer than pipe diameter).
- G. Riser Clamps: Steel, UL listed. MSS Type 8. Erico 510 or 511. Copper coated; Erico 368.
- H. Pipe Slides: Anvil, reinforced Teflon slide material (3/32-inch minimum thickness) bonded to steel; highly finished steel or stainless steel contact surfaces to resist corrosion; 60-80 PSI maximum active contact surface loading; steel parts 3/16-inch minimum thickness; attachment to pipe and framing by welding.
- I. Pipe Guides:
1. Furnish and install pipe guides on continuous runs where pipe alignment must be maintained. Minimum two on each side of expansion joints, spaced per manufacturer's recommendations for pipe size. Fasten guides securely to pipe and structure. Contact with chilled water pipe not to permit heat to be transferred in sufficient quantity to cause condensation on any surface.
 2. Furnish and install guides approximately four pipe diameters (first guide) and 14 diameters (second guide) away from each end of expansion joints. Guides are not to be used as supports and are in addition to other pipe hangers and supports.
- J. Thermal Hanger Shield Inserts:
1. 100-PSI (690-kPa) minimum compressive strength calcium silicate insulation, encased in sheet metal shield or polyisocyanurate rigid foam exceeding the load bearing weight of the pipe at the hanger point with a PVC vapor barrier.
 2. Material for Cold Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with vapor barrier or polyisocyanurate rigid foam with a PVC vapor barrier.
 3. Material for Hot Piping: Water-repellent-treated ASTM C533, Type 1 calcium silicate or polyisocyanurate rigid foam with a PVC vapor barrier.
 4. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
 5. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
 6. Insert Length: Extend 2-inches beyond sheet metal shield for piping operating below ambient air temperature.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

7. Thermal Hanger Shield Insulation Operating Temperature: Meet or exceed fluid temperature in pipe.

K. Freestanding Roof Supports: Polyethylene high-density UV resistant quick "pipe" block with foam pad.

2.3 WALL AND FLOOR SLEEVES

A. Pre-Engineered Firestop Pipe Penetration Systems: UL listed assemblies for maintaining fire rating of piping penetrations through fire-rated assemblies. Comply with ASTM E814.

B. Fabricated Accessories:

1. Steel Pipe Sleeves: Fabricate from Schedule 40 black or galvanized steel pipe. Remove end burrs by grinding.

2. Sheet Metal Pipe Sleeves: Fabricate from G-90 galvanized sheets closed with lock-seam joints. Provide the following minimum gauges for the sizes indicated:

a. Sleeve Size 4-inches in Diameter and Smaller: 18 gauge.

b. Sleeve Sizes 5-6-inches: 16 gauge.

c. Sleeve Sizes 7-inches and Larger: 14 gauge.

d. Fire-Rated Safing Material.

(1) Rockwool Insulation: Complying with FS-HH-I-558, Form A, Class IV, 6 pounds per cubic foot density with melting point of 1985 degrees F and K value of 0.24 at 75 degrees F.

(2) Calcium Silicate Insulation: Noncombustible, complying with FS-HH-I-523, Type II, suitable for 100 degrees F to 1200 degrees F service with K value of 0.40 at 150 degrees F.

2.4 BUILDING ATTACHMENTS

A. Beam Clamps:

1. MSS Type 19 and 23, wide throat, with retaining clip.

2. Universal Side Beam Clamp: MSS Type 20.

2.5 FLASHING

A. Steel Flashing: 26 gauge galvanized steel.

B. Safes: 8 mil thick neoprene.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- C. Caps: Steel, 22 gauge minimum, 16 gauge at fire-resistant structures.

2.6 MISCELLANEOUS METAL AND MATERIALS

A. General:

1. Provide miscellaneous supports and metal items, including materials, fabrication, fastenings and accessories required for finished installation, where indicated on drawings or otherwise not shown on drawings that are necessary for completion of the project. Contractor is responsible for their design.
 2. Fabricate miscellaneous units to size shapes and profiles indicated or, if not indicated, of required dimensions to receive adjacent other work to be retained by framing. Except as otherwise shown, fabricate from structural steel shapes and plates and steel bars, of welded construction using mitered joints for field connection. Cut, drill and tap units to receive hardware and similar items.
- B. Structural Shapes: Where miscellaneous metal items are needed to be fabricated from structural steel shapes and plates, provide members constructed of steel conforming with requirements of ASTM A36 or approved equivalent.
- C. Steel Pipe: Provide seamless steel pipe conforming to requirements of ASTM A53, Type S, Grade A, or Grade B. Weight and size required as specified.
- D. Fasteners: Provide fasteners of types as required for assembly and installation of fabricated items; surface-applied fasteners are specified elsewhere.
- E. Bolts: Low carbon steel externally and internally threaded fasteners conforming with requirements of ASTM A307; include necessary nuts and plain hardened washers. For structural steel elements supporting mechanical material or equipment from building structural members or connection thereto, use fasteners conforming to ASTM A325.
- F. Miscellaneous Materials: Provide incidental accessory materials, tools, methods, and equipment required for fabrication.
- G. Provide hot dipped galvanized components for items exposed to weather. Cold galvanize field-welded joints and components. Use materials compatible with system being supported (i.e. aluminum for aluminum ductwork, stainless steel for stainless steel ductwork).
- H. Use straps, threshold rods and wire with sizes required by SMACNA to support ductwork.
- I. Grout:
1. ASTM C1107, Grade B, factory mixed and packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

2. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
3. Properties: Nonstaining, noncorrosive, and non gaseous.
4. Design Mix: 5000-PSI (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Verify building materials to have hangers and attachments affixed in accordance with hangers to be used. Provide supporting calculations.
- B. Examine Drawings and coordinate for verification of exact locations of fire and smoke rated walls, partitions, floors and other assemblies. Indicate, by shading and labeling on Record Drawings such locations and label as "1-Hour Wall", "2-Hour Fire/Smoke Barrier", and the like. Determine proper locations for piping penetrations. Set sleeves in place in new floors, walls or roofs prior to concrete pour or grouting.
- C. Install hangers, supports, anchors and sleeves after required building structural work has been completed in areas where the work is to be installed. Coordinate proper placement of inserts, anchors and other building structural attachments.
- D. Equipment Clearances: Do not route ductwork, equipment, or piping through electrical rooms, transformer vaults, elevator equipment rooms, IT rooms, MPOE rooms, or other electrical or electronic equipment spaces and enclosures and the like. Within equipment rooms, provide minimum 3-foot lateral clearance from all sides of electric switchgear panels. Do not route ductwork, equipment, or piping above any electric power or lighting panel, switchgear, or similar electric device. Coordinate with Electrical and coordinate exact ductwork, equipment or pipe routing to provide proper clearance with such items.

3.2 HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- A. Hang rectangular sheet-metal ducts with a cross sectional area of less than 7 SF with galvanized strips of No. 16 USS gauge steel 1-inch wide, and larger ducts with steel angles and adjustable hanger rods similar to piping hangers. Support at a maximum of 8-foot on center.
- B. Support horizontal ducts within 24-inches of each elbow and within 48-inches of each branch intersection.
- C. Design hangers and supports to allow for expansion and contraction.
- D. Provide aluminum supports for aluminum ductwork.
- E. Provide stainless steel supports for stainless steel ductwork.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- F. Support vertical ducts at maximum intervals of 16-feet and at each floor.
- G. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- H. Install flexible ductwork per the more stringent of SMACNA HVAC Duct Construction Standards or the following:
 - 1. Support horizontal duct runs at not more than 4 feet intervals.
 - 2. Support vertical risers at not more than 6 feet intervals.
 - 3. Limit sag between support hangers to 1/2-inch per foot of spacing support.
 - 4. Supports shall be rigid and shall be not less than 1.5-inches wide at point of contact with the duct surface.
 - 5. Duct bends shall be not less than 1.5 duct diameter bend radius.
- I. Use double nuts and lock washers on threaded rod supports.
- J. Floor supports in mechanical rooms to be elevated 1-inch above finish floor and void space filled with masonry grout.
- K. Anchor ducts securely to building in such a manner as to prevent transmission of vibration to structure. Do not connect duct hanger straps directly to roof deck. Do not support ducts from other ducts, piping or equipment.
- L. Attach strap hangers installed flush with end of sheet-metal duct run to duct with sheet-metal screws.
- M. Construct exterior ductwork or ductwork which is otherwise exposed to weather watertight and slope 1/4-inch per foot to avoid standing water.
- N. Exposed ductwork hung in clean areas such as sanitary areas, pharmaceutical areas, wash down areas or food process areas to be installed using double end, food grade trapeze hanger rods suitable for use with food grade strut.
- O. Channel Support System Installation:
 - 1. Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.
 - 2. Field assemble and install according to manufacturer's written instructions.
- P. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- Q. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- R. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- S. Adjust hangers so as to distribute loads equally on attachments. Provide grout under supports to bring piping, ductwork and equipment to proper level and elevations.
- T. Prime paint ferrous nongalvanized hangers, accessories, and supplementary steel which are not factory painted.
- U. Horizontal Piping Hangers and Supports; Horizontal and Vertical Piping, and Hanger Rod Attachments:
 - 1. Factory fabricated horizontal piping hangers and supports complying with MSS SP-58, to suit piping systems and in accordance with manufacturer's published product information.
 - 2. Use only one type by one manufacturer for each piping service.
 - 3. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping.
 - 4. Pipe support spacing (pipe supported in ceiling or floor-supported) to meet latest applicable Code and manufacturer's requirements.
 - 5. Provide copper-plated hangers and supports for uninsulated copper piping systems.
- V. Plumber's Tape not permitted as pipe hangers or pipe straps.
- W. Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure. For horizontally hung grooved-end piping, provide a minimum of 2 hangers per pipe section.
- X. Pipe Ring Diameters:
 - 1. Uninsulated and Insulated Pipe, Except Where Oversized Pipe Rings are Specified: Ring inner diameter to suit pipe outer diameter.
 - 2. Insulated Piping Where Oversized Pipe Rings are Specified and Vibration Isolating Sleeves: Ring inner diameter to suit outer diameter of insulation or sleeve.
- Y. Oversize Pipe Rings: Provide oversize pipe rings of 2-inch and larger size.

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- Z. Pipe Support Brackets: Support pipe with pipe slides.
- AA. Steel Backing in Walls: Provide steel backing in walls to support fixtures and piping hung from steel stud walls.
- BB. Pipe Guides:
 - 1. Install on continuous runs where pipe alignment must be maintained. Minimum two on each side of expansion joints, spaced per manufacturer's recommendations for pipe size. Fasten guides to pipe structure. Contact with chilled water pipe does not permit heat to be transferred in sufficient quantity to cause condensation on any surface.
 - 2. Install approximately four pipe diameters (first guide) and 14 diameters (second guide) away from each end of expansion joints. Do not use as supports. Provide in addition to other required pipe hangers and supports.
- CC. Heavy-Duty Steel Trapeze Installation:
 - 1. Arrange for grouping of parallel runs of horizontal piping and support together on field fabricated, heavy-duty trapezes.
 - 2. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 3. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- DD. Group parallel runs of horizontal piping to be supported together on trapeze-type hangers. Maximum spacings: MSS SP-58.
- EE. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe.
- FF. Do not support piping from other piping.
- GG. Fire protection piping will be supported independently of other piping.
- HH. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated.
- II. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping" is not exceeded.
- JJ. Insulated Piping:

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1. Attach clamps and spacers to piping.
 - a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 2. Do not exceed pipe stress limits according to ASME B31.9.
 3. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 4. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields to span arc of 180 degrees.
 5. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.
 6. Shield Dimensions for Pipe, not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN8 to DN 90): 12-inches long and 0.048-inch thick.
 - b. NPS 4 (DN100): 12-inches long and 0.06-inch thick.
 - c. NPS 5 and NPS 6 (DN125 and DN150): 18-inches long and 0.06-inch thick.
 - d. NPS 8 to NPS 14 (DN200 to DN350): 24-inches long and 0.075-inch thick.
 - e. NPS 16 to NPS 24 (DN400 to DN600): 24-inches long and 0.105-inch thick.
 7. Pipes NPS 8 (DN200) and Larger: Include wood inserts.
 - a. Insert Material: Length at least as long as protective shield.
 8. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- KK. Pipe Anchors: Provide anchors to fasten piping which is subject to expansion and contraction, and adjacent to equipment to prevent loading high forces onto the equipment.
- LL. Pipe Curb Assemblies:

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1. Provide prefabricated units for roof membrane and insulation penetrations related to equipment. Coordinate with roofing system. Set supports on the structural deck. Do not set supports on insulation or roofing. Provide level supports by prefabricated pitch built into the curb.
 2. Provide for piping and electrical conduit which penetrates the structural roof deck to service equipment above the roof level (i.e., piping, electrical power and control wiring). Meet requirements of roof warranty.
- MM. Escutcheon Plates: Install around horizontal and vertical piping at visible penetrations through walls, partitions, floors, or ceilings, including penetrations through closets, through below ceiling corridor walls, and through equipment room walls and floors.
- NN. Vertical Piping:
1. Support with U-clamps fastened to wall to hold piping away from wall unless otherwise approved.
 2. Riser clamps to be directly under fitting or welded to pipe.
 - a. Riser to be supported at each floor of penetration.
 - b. Provide structural steel supports at the base of pipe risers. Size supports to carry forces exerted by piping system when in operation.
- OO. Piping Above Roof:
1. Provide engineered roof piping supports appropriate for installation and attachment to the roof structure or structure below roof (see Architectural and Structural Drawings for roof construction, building structural systems, and sloping requirements for insulation).
 2. Design a complete system unless specific details have been shown on Drawings.
 3. Provide calculations signed and stamped by a Structural Engineer, registered in the State where the project is located at, as part of submittals and coordinated shop drawings.
 4. Do not use freestanding supports unless approved by the Structural Engineer of Record.
 5. Provide miscellaneous metal and materials as specified in Miscellaneous Metal and Materials article, above.

3.3 WALL AND FLOOR SLEEVES

- A. Fabricated Pipe Sleeves:

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1. Provide either steel or sheet metal pipe sleeves accurately centered around pipe routes. Size such that piping and insulation, if any, will have free movement within the sleeve, including allowance for thermal expansion. Sleeve diameter to be determined by local seismic clearance requirements, and by waterproofing requirements.
 2. Length: Equal to thickness of construction penetrated, except extend floor sleeves 1-inch above floor finish.
 3. Provide temporary support of sleeves during placement in concrete and other work around sleeves. Provide temporary end closures to prevent concrete and other materials from entering pipe sleeves.
 4. Seal each end airtight with a resilient nonhardening sealer, UL listed, fire rated ASTM 814.
- B. Installation of metallic or plastic piping penetrations through non fire-rated walls and partitions and through smoke-rated walls and partitions:
1. Install fabricated pipe sleeve.
 2. After installation of sleeve and piping, tightly pack entire annular void between piping or piping insulation and sleeve identification with specified material.
 3. Seal each end airtight with a resilient nonhardening UL listed fire resistant ASTM 814.
- C. Piping Penetrations Through Fire-Rated (One to Three Hour) Assemblies:
1. Select and install pre-engineered pipe penetration system in accordance with the UL listing and manufacturer's recommendation.
 2. Provide proper sizing when providing sleeves or core-drilled holes to accommodate the penetration. Firestop voids between sleeve or core-drilled hole and pipe passing through to meet the requirements of ASTM E814.

3.4 BUILDING ATTACHMENTS

- A. Factory fabricated attachments complying with MSS SP-58, selected to suit building substructure conditions and in accordance manufacturer's published product information.
- B. Select size of building attachments to suit hanger rods.
- C. Space attachments within maximum piping span length indicated in MSS SP-58.
- D. Install building attachments within concrete slabs or attach to structural steel or wood. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

changes in direction of piping.

- E. Attachment to Wood Structure: Anvil side beam bracket Figure 202 for attachment to wooden beam or approved attachment for a wood structure.
- F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- G. Bolting: Provide bored, drilled or reamed holes for bolting to miscellaneous structural metals, frames or for mounts or supports. Flame cut, punched or hand sawn holes will not be accepted.
- H. Anchor Bolts:
 - 1. Install anchor bolts for mechanical equipment, piping and ductwork as required. Tightly fit and clamp base-supported equipment anchor bolts at equipment support points. Provide locknuts where equipment, piping and ductwork are hung.

3.5 FLASHING

- A. Flash and counterflash where piping, ductwork and equipment passes through weather or waterproofed walls, floors, and roofs.
- B. Provide 12-inch minimum height curbs for roof-mounted mechanical equipment. Flash and counter flash with galvanized steel, soldered and waterproofed.

3.6 MISCELLANEOUS METAL AND MATERIALS

- A. General: Verify dimensions prior to fabrication. Form metal items to accurate sizes and configurations as indicated on drawings and otherwise required for proper installation; make with lines straight and angles sharp, clean and true; drill, countersink, tap, and otherwise prepare items for connections with work of other trades, as required. Fabricate to detail of structural shapes, plates and bars; weld joints where practicable; provide bolts and other connection devices required. Include anchorages; clip angles, sleeves, anchor plates, and similar devices. Hot dipped galvanize after fabrication items installed in exterior locations. Set accurately in position as required and anchor securely to building construction. Construct items with joints formed for strength and rigidity, accurately machining for proper fit; where exposed to weather, form to exclude water.
- B. Finishes:
 - 1. Ferrous Metal: After fabrication, but before erection, clean surfaces by mechanical or chemical methods to remove rust, scale, oil, corrosion, or other substances detrimental to bonding of subsequently applied protective coatings. For metal items exposed to weather or moisture, galvanize in manner to obtain G90 zinc coating in accordance with ASTM A123. Provide other non-galvanized

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

ferrous metal with 1 coat of approved rust-resisting paint primer, in manner to obtain not less than 1.0 mil dry film thickness. Touch-up damaged areas in primer with same material, before installation. Apply zinc coatings and paint primers uniformly and smoothly; leave ready for finish painting as specified elsewhere.

2. Metal in Contact with Concrete, Masonry and Other Dissimilar Materials: Where metal items are to be erected in contact with dissimilar materials, provide contact surfaces with coating of an approved zinc-chromate primer in manner to obtain not less than 1.0 mil dry film thickness, in addition to other coatings specified in these specifications.
 3. For Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A780.
- C. Coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, sleeves, anchor bolts and miscellaneous items having integral anchors, which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to project site.
 - D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing miscellaneous metal fabrications to in-place construction; including, threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws and other connectors as required. Avoid cutting concrete reinforcing when drilling for inserts. Reference structural drawings and reinforcing shop drawings and determine locations of stirrups prior to drilling into concrete.
 - E. Cutting, Fitting and Placement: Perform cutting, drilling and fitting required for installation of miscellaneous metal fabrications. Set work accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Provide temporary bracing or anchors in formwork for items, which are to be built into concrete masonry or similar construction.
 - F. Field Welding: Comply with AWS Code for procedures of manual shielded metal-arc welding, appearance and quality of welds made, and methods used in correcting welding work.
 - G. Setting Loose Plates: Clean concrete and masonry bearing surfaces of any bond reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of bearing plates.
 - H. Set loose leveling and bearing plates on wedges, or other adjustable devices. After the bearing members have been positioned and plumbed, tighten the anchor bolts. Do not remove wedges or shims, but if protruding, cut-off flush with edge of the bearing plate before packing with grout. Use metallic non-shrink grout in concealed locations where not exposed to moisture; use non-metallic non-shrink grout in exposed locations, unless

HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

otherwise indicated.

- I. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.
- J. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- K. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- L. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.
- M. Provide galvanized components for items exposed to weather.

3.7 FIRE RATED SUPPORTS

- A. Provide fire rated support as required by Codes.

END OF SECTION

This page intentionally left blank

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Vibration Isolation
2. Seismic Restraint Devices
3. Factory Finishes
4. Seismic-Bracing/Restraint Devices/Systems for Equipment, Piping and Ductwork

B. General:

1. Vibration isolation for mechanical ductwork, piping and equipment.
2. Seismic restraint for mechanical ductwork, piping and equipment.
3. Seismic Certification for equipment, hangers and systems.
4. Special inspections for systems.

C. Scope of Work:

1. Vibration isolation and seismic restraint of new equipment and systems within project boundary defined in architectural drawings.
2. Vibration isolation and seismic restraint of new equipment and systems in existing buildings to points of connection with existing systems.
3. Seismic restraint of existing systems and equipment shown on Drawings, within project boundary defined in architectural drawings.
4. Provide supplementary structural steel for seismic restraint systems. No hanging from roof deck is permitted on this project, unless specifically allowed by Structural Engineer of Record in writing prior to bid.

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Vibration Isolation:
 - a. Product Data: Provide catalog data indicating size, type, load and deflection of each isolator; and percent of vibration transmitted based on lowest disturbing frequency of equipment.
 - b. Shop Drawings: Showing complete details of construction for steel and concrete bases including:
 - (1) Fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment and cantilever loads.
 - (2) Equipment mounting holes.
 - (3) Dimensions.
 - (4) Size and location of concrete and steel bases and curbs.
 - (5) Isolation selected for each support point.
 - (6) Details of mounting brackets for isolator.
 - (7) Weight distribution for each isolator.
 - (8) Details of seismic snubbers.
 - (9) Code number assigned to each isolator.
 - c. Design calculations: Provide calculations for selecting vibration isolators and for designing vibration isolation bases.
 - 2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
 - 3. Seismic Restraint:

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- a. Shop Drawings: Show compliance with requirements of Quality Assurance article of this Section. Shop drawings to be stamped by a professional Structural Engineer licensed in State of Oregon.
 - b. Calculations: Submit seismic calculations indicating restraint loadings resulting from design seismic forces. Include anchorage details and indicate quantity, diameter and depth of penetration of anchors. Calculations certified by professional Structural Engineer licensed in State of Oregon.
4. Seismic Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter and depth of penetration of anchors.
 5. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y and z planes.
 6. Welding certificates.
 7. Equipment Certification: Provide seismic certification for equipment as noted in Seismic Design Summary or schedules on Drawings.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 1. Vibration Isolation:
 - a. Except for packaged equipment with integral isolators, single manufacturer selects and furnishes isolation required.
 - b. Deflections indicated on drawings are minimum actual static deflections for specific equipment supported.
 - c. Isolator Stability:
 - (1) Size springs of sufficient diameter to maintain stability of equipment being supported. Spring diameters not less than 0.8 of compressed height at rated load.
 - (2) Springs have minimum additional travel to solid equal to 50 percent of rated deflection.
 - (3) Springs support 200 percent of rated load, fully compressed, without deformation or failure.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- d. Maximum Allowable Vibration Levels: Peak vibration velocities not exceed 0.08 in/sec. Correct equipment operating at vibration velocities that exceed this criteria.

2. Seismic Restraint:

- a. Code and Standard Requirements:
 - (1) Seismic restraint of equipment, piping and ductwork to be in accordance with latest enacted version of ASCE 7-16.
- b. Confirm Seismic Control requirements in Division 01, General Requirements and Structural documents.
- c. Equipment Importance Factor: 1.0.
- d. Seismic Design Category: D.
- e. Building Occupancy Category: III.
- f. Certification: See Seismic Design Table or schedules on Drawings for equipment, systems and seismic-restraint devices designated to have seismic certification/qualification. Horizontal and vertical load testing and analysis performed according to ASCE 7-16. Anchorage systems to bear anchorage preapproval number from an agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing or calculations, if preapproved ratings are not available. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be sealed by qualified licensed professional engineer in State of Oregon. Testing and calculations must include both shear and tensile loads and one test or analysis at 45 degrees to weakest mode.
- g. Seismic restraint and anchorage of permanent equipment and associated systems listed below to building structure be designed to resist total design seismic force prescribed in local building code:
 - (1) Floor- or roof-mounted equipment weighing 400 pounds or greater.
 - (2) Suspended, wall-mounted or vibration isolated equipment weighing 20 pounds or greater.
 - (3) In-line duct devices connected to ductwork weighing 75 pounds or greater.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- h. Where required, seismic sway bracing of suspended duct and piping meet following:
 - (1) Pipe and duct runs requiring seismic bracing have minimum of two traverse braces and one longitudinal brace. Longitudinal (or traverse) brace at 90 degree change in direction may act as traverse (or longitudinal) brace if located within 2-feet of change in direction.
 - (2) Seismic bracing may not pass through seismic separation joint. Pipe or duct runs that pass through seismic separation joint must be restrained within 5-feet of both sides of separation.
 - (3) Seismic brace assembly spacing not to exceed 40-feet transverse and 80-feet longitudinal.
- i. Seismic restraints may be omitted from suspended piping and duct if following conditions are satisfied:
 - (1) For piping or ducts supported by rod hangers 12-inches or less in length from top of duct to bottom of structural support. Top connections to structure have swivel joints, eye bolts, or vibration isolation hangers for entire length of system run.
 - (2) Lateral motion of system will not cause damaging impact with surrounding systems or cause loss of system vertical support.
 - (3) System must be welded steel pipe, brazed copper pipe, sheet metal duct or similar ductile material with ductile connections.
- C. Seismic restraints, including anchors to building structure, be designed by registered professional Structural Engineer licensed in State of Oregon. Design includes:
 - 1. Number, size, capacity and location of anchors for floor- or roof-mounted equipment. For curb-mounted equipment, provide design of attachment of both unit to curb and curb to structure.
 - 2. Number, size, capacity and location of seismic restraint devices and anchors for vibration-isolation and suspended equipment. Provide calculations and test data verifying horizontal and vertical ratings of seismic restraint devices.
 - 3. Number, size, capacity and location of braces and anchors for suspended piping and ductwork on as-built plan drawings.
 - 4. Maximum seismic loads to be indicated on drawings at each brace location. Drawings bear stamp and signature of registered professional Structural Engineer who designed layout of braces.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Seismic Snubber Units: Furnish replacement neoprene inserts for snubbers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Vibration Isolation:
 - 1. The VMC Group
 - 2. B-Line Systems, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
 - 5. M.W. Saussé - Vibrex
 - 6. Where Mason numbers are specified, equivalent products by listed manufacturers are acceptable.
- B. Seismic Restraint Devices:
 - 1. The VMC Group
 - 2. B-Line Systems, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
 - 5. M.W. Saussé - Vibrex
 - 6. California Dynamics Corporation
 - 7. Cooper B-Line Tolco
 - 8. Unistrut Diversified Products Co.; Wayne Manufacturing Division.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

9. Hilti, Inc.
- C. Factory Finishes:
1. Kynar 500 Fluoropolymer Coating
 2. Or approved equivalent.
- D. Seismic-Bracing/Restraint Devices/Systems for Equipment, Piping and Ductwork:
1. The VMC Group
 2. Kinetics Noise Control, Inc.
 3. Mason Industries, Inc.
 4. Hilti, Inc.
 5. Cooper B-Line, Inc.
 6. California Dynamics Corporation
 7. Unistrut
 8. ISAT, Inc.
 9. Where Mason numbers are specified, equivalent products by listed manufacturers are acceptable.

2.2 VIBRATION ISOLATION

- A. Type 1 - Neoprene Pad: Natural rubber waffle pads, arranged in single or multiple layers, 3/4-inch thick per layer with pattern repeating on 1/2-inch centers; 50 durometer hardness; maximum loading 60 PSI. Minimum 1/4-inch thick steel load distribution plate and 1/16-inch shim plates between layers, factory cut to sizes matching requirements of supported equipment. Molded bridge with neoprene anchor bolt bushing and flat washer face to prevent metal to metal contact. Number of layers required for equipment scheduled. Mason Type: Super WMH.
- B. Type 2 - Neoprene Mount: Double-deflection type, with ductile-iron housing containing two separate and opposing, oil-resistant natural rubber or bridge bearing neoprene elements, factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Neoprene elements to prevent metal to metal contact during normal operation. Minimum static deflection of 0.30-inches. Mason Type: BR.
- C. Type 3 - Spring: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

2. Minimum Additional Travel: 50 percent of required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch thick, natural rubber or bridge bearing neoprene isolator pad attached to baseplate underside. Baseplates limit floor load to 100 PSIG (690 kPa).
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
 7. Brackets: Manufacturer's standard bracket, utilize height saving brackets to accommodate height restrictions.
 8. Mason Type: SLFH or SLF.
- D. Type 4a - Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
1. Housing: Steel with resilient vertical-limit stops (out of contact during normal operation) to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch thick, natural rubber or bridge bearing neoprene isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation. Restraining bolts have large rubber grommets to provide cushioning in vertical and horizontal directions. A minimum clearance of 3/8-inch maintained around restraining bolts so as not to interfere with spring action.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Brackets: Manufacturer's standard bracket, utilize height saving brackets to accommodate height restrictions.
 7. Mason Type: SLR.
- E. Type 4b - Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint with neoprene acoustical cup, spring inspection ports and rebound adjustment ports.
 2. Base: Factory drilled for bolting to structure.
 3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel before contacting a resilient collar.
 4. Brackets: Manufacturer's standard bracket, utilize height saving brackets to accommodate height restrictions.
 5. Mason Type: SSLFH.
- F. Type 5a - Restrained Elastomeric Hangers: Double-deflection type, with molded, oil-resistant natural rubber or bridge bearing neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range. Seismic rebound steel and bonded LDS rubber washer to limit upward seismic movement. Mason Type: RWHD.
- G. Type 5b - Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 15 degrees of angular hanger-rod misalignment from vertical without binding or reducing isolation efficiency.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 7. Mason Type: 30N.
- H. Type 5c - Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 15 degrees of angular hanger-rod misalignment from vertical

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 8. Mason Type: RW30.
- I. Type 6 - Horizontal Thrust Restraints: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.
 8. Mason Type: WBI or WBD.
- J. Type 7 - Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on isolation material of 500 PSIG (3.45

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

MPa) and for equal resistance in all directions. Mason Type: ADA.

- K. Type 8 - Resilient Pipe Vertical Sliding Guide: Telescopic arrangement of two steel tubes separated by a minimum of 1/2-inch thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin be removable and reinsertable to allow for selection of pipe movement. Guides be capable of motion to meet location requirements. Mason Type: VSG. Provide pipe expansion hangers to control load shifts as the riser expands or contracts, Mason HES.
- L. Type FC-1, Flexible duct connectors. See Specification Section 23 33 00 Air Duct Accessories.
- M. Type FC-2A, Flexible Pipe Connector, Steel:
1. 321 stainless steel, closed pitch, annular corrugated hose.
 2. Exterior Sleeve: 304 stainless steel, braided.
 3. Pressure Rating: 125 PSI at 70 degrees F for 12-inch and smaller pipe.
 4. Joint: ANSI Class 150 carbon steel flanges.
 5. Size: Use pipe sized units.
 6. Minimum Allowable Offset: 3/4-inch on each side of installed center line.
 7. Basis of Design: Metraflex Model MLP.
- N. Type FC-2B, Flexible Pipe Connector, Copper:
1. Inner Hose: Bronze, close pitch, annular corrugated hose.
 2. Exterior Sleeve: Braided bronze (for piping over 2-inches, to be 3 pound braided stainless steel).
 3. Minimum Allowable Pressure Rating: 125 PSI at 70 degrees F.
 4. Joint: Sweat ends.
 5. Size: Use pipe sized units.
 6. Minimum Allowable Offset: 3/8-inch on each side of installed center line.
 7. Basis of Design: Metraflex Model BBS.
- O. Type FC-2C, Flexible Pipe Connector, Gas:
1. Inner Hose: 304 stainless steel.
 2. Exterior Sleeve: Braided, 304 stainless steel.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

3. Minimum Allowable Pressure Rating: 150 PSI at 70 degrees F up to 4-inch pipe.
 4. Joint: Threaded carbon steel.
 5. Minimum Allowable Offset: 3/4-inch on each side of installed center line.
 6. Basis of Design: Metraflex GASCT.
- P. Type FC-3, Flexible Compensator, Double Sphere:
1. Body: Molded twin spherical type. Neoprene with internal cord or wire.
 2. Minimum Pressure Rating, Sizes 2-inch to 12-inch: 225 PSI at 170 degrees F.
 3. Minimum Pressure Rating, Sizes 14-inch to 20-inch: 125 PSI at 170 degrees F.
 4. Minimum Allowable Compression: 1-1/2 inches.
 5. Minimum Allowable Elongation: 1-1/8 inches.
 6. Minimum Allowable Offset: 1-1/8 inches.
 7. Minimum Allowable Angular Movement: 20 degrees.
 8. Joint: Steel flanges.
 9. Accessories: Galvanized aircraft-type cable or control rods to prevent over extension.
 10. Basis of Design: Metraflex Doublesphere.

2.3 SEISMIC RESTRAINT DEVICES

- A. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5, with a flat washer face.
- B. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts and replaceable resilient isolation washers and bushings. Snubber load rating to match equipment size. Mason Type: Z-1011 or Z-1225.
1. Anchor bolts for attaching to concrete be seismic-rated, drill-in and stud-wedge or female-wedge type.
 2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- C. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement. Mason Type: SCB.
- D. Anchor Bolts: Seismic-rated, drill-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.

2.4 FACTORY FINISHES

- A. Provide manufacturer's standard prime-coat finish ready for field painting. Units mounted outdoors exposed to weather: Epoxy powder coated, with 1000 hour salt spray rating per ASTM B-117. For high levels of corrosion protection utilize:
 - 1. Conform to AAMA 605.2.
 - 2. Apply coating following cleaning and pretreatment.
 - 3. Cleaning: AA-C12C42R1X.
 - 4. Dry system before final finish application.
 - 5. Total Dry Film Thickness: Approximately 1.2 mils, when baked at 450 degrees F for 10 minutes.
- B. Finish:
 - 1. Manufacturer's standard paint applied to factory-assembled and factory-tested equipment before shipping.
 - 2. Powder coating on springs and housings.
 - 3. Hardware be electrogalvanized. Hot-dip galvanize metal components for exterior use.
 - 4. Baked enamel for metal components on isolators for interior use.
 - 5. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

2.5 SEISMIC-BRACING/RESTRAINT DEVICES/SYSTEMS FOR EQUIPMENT, PIPING AND DUCTWORK

- A. General Requirements for Restraint Components: Rated strengths, features and applications to be as defined in reports by agency acceptable to authorities having jurisdiction.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- B. Structural Safety Factor: Allowable strength in tension, shear and pullout force of components be at least four times maximum seismic forces to which they will be subjected.
- C. Anchor bolts for attaching to concrete to be seismic-rated, drill-in and stud-wedge or female-wedge type.
- D. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
- E. Maximum 1/4-inch air gap and minimum 1/4-inch thick resilient cushion.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Provide mounts for equipment installed outdoors for wind loads of 30 lbs. psf applied to any exposed surface of isolated equipment.
- B. Do not install equipment or pipe which makes rigid contact with building slabs, beams, studs, walls, etc.
- C. Anchor baseplate to floor or structure. Provide rubber grommets and washers to isolate bolt from base plate. Under no circumstances is isolation efficiency to be destroyed when bolting isolators to floor.
- D. Building Penetrations: Isolate water piping and ductwork penetrating wall, ceilings, floors or shafts from structure by piping isolator or by 3/8-inch thick foamed rubber insulation. Install units flush with finished structure face, using one for each side as required. Cut units to length if longer than structure thickness. Caulk around pipe or duct at equipment room wall.
- E. Provide roof curbs, equipment supports and roof penetrations. Work to maintain roof warranty. Coordinate location, size, structural connections/requirements and flashing prior to installation.
- F. Install Type 6 horizontal thrust restraints at centerline of thrust, symmetrical on either side of equipment.
- G. Vibration isolators must not cause change of position of equipment or piping which would stress piping connections or misalignment shafts or bearings. Isolated equipment is to be level and in proper alignment with connecting ducts and pipes.
- H. Pipe Hangers in Equipment Rooms: Support water and gas piping connected to rotating equipment within equipment rooms on spring and neoprene hangers. The first three hangers from a piece of vibrating equipment are to have a minimum of 1/2 static deflection of equipment isolators. Other isolators should have a minimum of 1/4 static deflection of equipment isolators.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- I. Examination:
 - 1. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances and other conditions affecting performance.
 - 2. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.
- J. Testing: Perform following field quality-control testing:
 - 1. Isolator seismic-restraint clearance.
 - 2. Isolator deflection.
 - 3. Snubber minimum clearances.
- K. Adjusting:
 - 1. Adjust snubbers according to manufacturer's written recommendations.
 - 2. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.
- L. Cleaning: After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt and debris.
- M. Demonstration: Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain air-mounting systems. Reference Division 01, General Requirements.

3.2 VIBRATION ISOLATION

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Vibration isolators must be installed in strict accordance with manufacturer's written instructions and certified submittal data.
- D. Install isolation as indicated on drawings by type and location and where indicated below.
- E. Equipment Vibration Isolation Schedule:

Equipment	Size	Vibration Isolator Type	Minimum Deflection
-----------	------	-------------------------	--------------------

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

			(in)
Fan-coils, Unit Heaters, Fan-Powered Terminal Units	All	Type 5B, or 5C, FC-1,2	0.75
Condensing Units	0 to 4.5 tons	Type 1 or 2	0.3
Condensing Units	5+ tons	Type 4A	2.5
Axial, Cabinet, Centrifugal Inline Fans	0 to 23.5-inch diameter	Type 3, 4A, 4B, 5B, or 5C, FC-1	0.75
Axial, Cabinet, Centrifugal Inline Fans	24-inch+ diameter	Type 3, 4A, 4B, 5B, or 5C, FC-1	1.5

F. Isolation Mounts:

1. Install minimum of four seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts.
3. Provide flexible piping connection and flexible ductwork connection to equipment with isolation mounts or bases.

G. Isolating Hangers:

1. Support piping and ductwork connected to isolated equipment within equipment rooms on isolating hangers as scheduled on drawings. Unless otherwise noted, first three hangers from isolated equipment to have a minimum of 1/2 static deflection of equipment isolators. Other isolating hangers to have a minimum of 1/4 static deflection of equipment isolators.
2. Position isolating hanger elements as high as possible in hanger rod assembly, but not in contact with building structure. Install hangers so that hanger housing may rotate full 360 degrees about rod axis without contacting any object.
3. Unless otherwise noted, air supply units with internally isolated fans do not require isolating hangers for connecting pipes and ductwork.
4. Where parallel running pipes are hung together on an isolated trapeze, provide isolator deflections for largest determined by provisions for pipe isolation. Do not mix isolated and non-isolated pipes in same trapeze.
5. Install limit stops so they are out of contact during normal operation.

H. Adjusting:

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

1. Adjust isolators after piping systems have been filled and equipment is at operating weight.
2. 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.
3. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.

3.3 SEISMIC RESTRAINT DEVICES

- A. Reference 3.01, General Installation Requirements.
- B. Install in strict accordance with manufacturer's written instructions and certified submittal data.
- C. Install and adjust seismic restraints so equipment, piping and ductwork supports are not degraded by restraints.
- D. Restraints must not short circuit vibration isolation systems or transmit objectionable vibration or noise.
- E. Install restraining cables at each trapeze, individual pipe hanger and hanging vibration isolated equipment. Provide restraining cables in each of the four directions of movement. Install restraining cables no less than 45 Degrees from vertical. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
- F. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

3.4 FACTORY FINISHES

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Finishes to be factory-applied. No field patching or holidays allowed.

3.5 SEISMIC-BRACING/RESTRAINT DEVICES/SYSTEMS FOR EQUIPMENT, PIPING AND DUCTWORK

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.

VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT

- C. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Plastic Nameplates
 - 2. Tags
 - 3. Plastic Pipe Markers
 - 4. Plastic Duct Markers

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Schedules:
 - a. Submit valve schedule for each piping system, in tabular format using Microsoft Word or Excel software. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shutoff and similar special uses by special "flags" in margin of schedule. In addition to mounted copies, furnish extra copies for maintenance manuals.
 - 2. Submit schedule of identification type, including material, for each class of tagged item.
 - 3. Submit locations at which Valve Schedules will be installed.

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Manufacturer's Qualifications: Firms regularly engaged in manufacture of identification devices of types and sizes required.
 - 2. Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices unless otherwise indicated.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 PLASTIC NAMEPLATES

- A. Manufacturers:
 - 1. Brady Corporation
 - 2. Brimar
 - 3. Champion America
 - 4. Craftmark
 - 5. Seton
- B. Description: Engraving stock melamine plastic laminate in the size and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color), punched for mechanical fastening except where adhesive mounting is necessary because of substrate. Provide 1/8-inch thick material.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/2-inch.
 - 3. Background Color: Black.
 - 4. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

5. Access Panel Markers: Manufacturer's standard 1/16-inch thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve or devices/equipment. Include center hole to allow attachment.

2.2 TAGS

- A. Manufacturers:
 1. Brady Corporation
 2. Brimar
 3. Champion America
 4. Craftmark
 5. Seton
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 2-inch diameter.
- C. Metal Tags: Polished Brass with stamped letters; tag size minimum 2-inch diameter with smooth edges.
- D. Valve designations to be coordinated with existing valve identifications to ensure no repetitive designations are utilized.
- E. Chart/Schedules: Valve Schedule Frames. For each page of a valve schedule, provide glazed display frame with removable mounting as appropriate for wall construction upon which frame is to be mounted. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.
- F. Valve Tag Fasteners: Solid brass chain (wire link or beaded type), or solid brass S-hooks.
- G. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
 1. Size: Approximately 4 by 7-inches.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 4. Color: Yellow background with black lettering.

2.3 PLASTIC PIPE MARKERS

- A. Manufacturers:

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

1. Brady Corporation
 2. Brimar
 3. Champion America
 4. Craftmark
 5. Seton
- B. Color: Conform to ASME A13.1 and ANSI Z535.1.
- C. Plastic Pipe Markers (for external diameters of 6-inches and larger including insulation): Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers (for external diameters less than 6-inches including insulation): Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings. Minimum information indicating flow direction arrow and identification of fluid being conveyed.
- E. Lettering:
1. 3/4-inch to 1-1/4-inch Outside Diameter of Insulation or Pipe: 8-inch long color field, 1/2-inch high letters.
 2. 1-1/2-inch to 2-inch Outside Diameter of Insulation or Pipe: 8-inch long color field, 3/4-inch high letters.
 3. 2-1/2-inch to 6-inch Outside Diameter of Insulation or Pipe: 12-inch long color field, 1-1/4-inch high letters.
 4. 8-inch to 10-inch Outside Diameter of Insulation or Pipe: 24-inch long color field, 2-1/2-inch high letters.
 5. Over 10-inch Outside Diameter of Insulation or Pipe: 32-inch long color field, 3-1/2-inch high letters.

2.4 PLASTIC DUCT MARKERS

- A. Manufacturers:
1. Brady Corporation
 2. Brimar
 3. Champion America

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

4. Craftmark
 5. Seton
 6. Or approved equivalent.
- B. General: Manufacturer's standard laminated plastic, color-coded duct markers. Supply separate color codes for supply, exhaust, outside, return air and hazardous exhaust lab, chemical, fume hood, isolation room systems.
- C. Include the Following Nomenclature:
1. Direction of air flow.
 2. Duct service (supply, return, general exhaust, outdoor air), kitchen exhaust, dishwasher exhaust, fume hood exhaust, isolation room exhaust, etc.

PART 3 - EXECUTION

3.1 GENERAL - INSTALLATION

- A. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates riveted to equipment body.
- B. Identify ductwork with plastic ductmarkers.
- C. Identify piping, concealed or exposed, with plastic pipe markers.
- D. Coordinate names, abbreviations and other designations used in mechanical identification work with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
- E. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples: Chiller No. 3, Air Handling Unit No. 42, Standpipe F12, and the like).
- F. Degrease and clean surfaces to receive adhesive for identification materials.
- G. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.
- H. Coordinate with the facility maintenance personnel to ensure consistency with the existing tagging system.

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

- I. Install all products in accordance with manufacturer's instructions.
- J. Manual Balancing Dampers: Provide 12-inch long orange marker ribbon to end of balancing damper handle.

3.2 PLASTIC NAMEPLATES

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners.
- B. Identify control panels and major control components outside panels with plastic nameplates riveted to equipment body.
- C. Identify thermostats with nameplates.

3.3 TAGS

- A. Use metal tags on piping 3/4-inch diameter and smaller.
- B. Tag balancing valves and major dampers with balanced GPM or CFM indicated after balancing is completed and accepted.
- C. Install tags with corrosion resistant chain.
- D. Small devices, such as in-line pumps, may be identified with tags.
- E. Identify valves with metal tags. Indicate valve function and the normally open or closed positions on the valve tag.
- F. Identify air terminal units and radiator valves with numbered plastic tags.
- G. Tag automatic controls, instruments, and relays. Key to control schematic.
- H. Install valve schedule at each mechanical room.

3.4 PLASTIC PIPE MARKERS

- A. Install plastic pipe markers complete around pipe in accordance with manufacturer's instructions.
- B. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20-feet (reduced to 10-feet in congested areas and mechanical equipment rooms) on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction. Locate near branches, valves, control devices, equipment connections, access doors, floor/wall penetrations.

IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

3.5 PLASTIC DUCT MARKERS

- A. Identify air supply, return, exhaust, isolation room exhaust, and outside air intake ductwork with duct markers, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork identification color). Identify with air handling unit identification number and area served. Locate identification at air handling unit, in mechanical rooms, at each side of penetration of structure or enclosure, at each obstruction, and within view of access doors/panels. In each space where ductwork is exposed, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment) and at 50 foot spacing along exposed runs. Where noted on Drawings, identify ductwork in exposed/public locations.

- B. Access Doors: Provide duct markers on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions.

END OF SECTION

This page intentionally left blank

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. General Requirements and Procedures
2. Fundamental Air Systems Balancing Procedures
3. Temperature Control Verification
4. Constant Volume Air Systems Balancing Procedures
5. Pre-Balance Reporting
6. Final Reports:
 - a. Report Requirements
 - b. General Report Data
 - c. System Diagrams
 - d. Air Handling Units
 - e. Fans
 - f. Duct Traverses
 - g. Diffusers/Registers/Grilles
 - h. Instrument Calibration
7. Additional Tests

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- B. In addition, provide:
1. Quality-Assurance Submittals: Submit two copies of evidence that the Testing, Adjusting, and Balancing (TAB) Agent and Project's TAB team members meet the qualifications specified in the "Quality Assurance" Article below.
 2. Pre-Construction Phase Report:
 - a. Provide a pre-construction phase TAB Plan at least two weeks prior to the commencement of TAB work. This report is to include:
 - (1) A complete set of report forms intended for use on the Project, with data filled in except for the field readings. Forms to be Project-specific.
 - (2) Marked up shop drawings identifying all HVAC equipment to be balanced, and associated outlets and terminal devices.
 - (3) Identification of the type, manufacturer, and model of the actual instruments to be used, and clear indication of which instrument will be used to take each type of reading. Calibration certifications to be included.
 - (4) A narrative of Project-specific and/or non-standard TAB procedures to be used, and the equipment or systems to which they apply.
 3. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit two copies of the Contract Documents review report as specified in Part 3 of this Section.
 4. Strategies and Procedures Plan: Submit two copies of the TAB strategies and step-by-step procedures as specified in Part 3 of this Section. Include a complete set of report forms intended for use on this Project.
 5. Specify reports required because of editing procedures in Part 3 of this Section.
 6. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by the TAB Agent.
 7. Sample Report Forms: Submit two sets of sample TAB report forms.
 8. Test Instrument Calibration: Submit proof of calibration within the last 6 months.
 9. Final Report.
 10. Provide additional submittals to commissioning authority as dictated in Commissioning Specifications.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

1.5 QUALITY ASSURANCE

- A. Quality Assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Acceptable TAB Agencies:
 - a. Oregon:
 - (1) Air Introduction and Regulations Inc.
 - (2) Accurate Air Balance, Inc.
 - (3) Neudorfer Engineers
 - (4) Northwest Engineering Services
 - (5) Air Balancing Specialty Inc.
 - (6) Precision Test & Balance, Inc.
 - (7) Testcomm
 - (8) American Commissioning and LEED Consultants, Inc.
 - 2. Balance Firm Qualifications:
 - a. General:
 - (1) Procure services of independent TAB agency to balance, adjust and test water circulating and air moving equipment and air distribution or exhaust systems. Minimum experience: 5 years.
 - (2) Provide proof of testing agency having successfully completed at least five projects of similar size and scope.
 - b. Testing and Balancing firm is certified by NEBB or AABC and has a NEBB Certified Professional (CP) or a AABC Test and Balancer Engineer (TBE) on staff.
 - c. Industry Standards: Testing and Balancing will conform to NEBB or AABC, and American National Standards Institute (ANSI) as follows:
 - (1) NEBB: Comply with Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- (2) AABC: Comply with National Standards for Total System Balance.
- (3) ANSI:
 - (a) S1.4 Specifications for sound level meters.
 - (b) S1.11 Specifications for Octave-Band and Fractional-Octave-Band analog and digital filters.
 - (c) ANSI S1.13 Methods for the Measurement of Sound Pressure Levels.
- d. Test Observation: If requested, conduct tests in the presence of the Commissioning Authority, AHJ, Architect or the Architect's representative.

3. Noise Criteria:

- a. Noise levels in all 8 octave bands due to equipment and duct systems are not to exceed the following NC levels:

TYPE OF ROOM	NC LEVEL
Bathrooms and Toilet Rooms	35-40
Conference Room	30-35
Corridors (Public)	35-40
Lobbies, Waiting Areas	35-40
Offices, Large Open (3 or more occupants)	35-40
Offices, Small Private (2 or fewer occupants)	30-35
Kitchens	40-45
Classrooms (Small, Medium, Large)	30-35
Cafeteria/Dining	35-40
All Others	35-40

- b. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
- c. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

4. Code Compliance: Perform tests in the presence of the Authority Having Jurisdiction (AHJ) where required by the Authority Having Jurisdiction (AHJ).
5. Owner Witness: Perform tests in the presence of the Commissioning Authority, Architect, Architect's Representative, or Owner's representative.
6. Engineer Witness: The engineer or engineer's representative reserves the right to observe tests or selected tests to assure compliance with the specifications.
7. Simultaneous Testing: Test observations by the AHJ, the Owner's Authorized Representative and the engineer's representative need not occur simultaneously.
8. Do not perform TAB work until heating, ventilating, and air conditioning equipment has been completely installed and is operating continuously as required.
9. Conduct air testing and balancing with clean filters in place. Clean strainers prior to performing hydronic testing and balancing.
10. TAB Conference: Meet with the Commissioning Authority, Owner's and the Architect's representatives on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days advance notice of scheduled meeting time and location.
 - a. Agenda Items: Include at least the following:
 - (1) Submittal distribution requirements.
 - (2) Contract Documents examination report.
 - (3) TAB plan.
 - (4) Work schedule and Project site access requirements.
 - (5) Coordination and cooperation of trades and subcontractors.
 - (6) Coordination of documentation and communication flow.
11. Certification of TAB Reports: This certification includes the following:
 - a. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - b. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

12. TAB Reports: Use standard forms from NEBB or AABC.
13. Instrumentation Type, Quantity, and Accuracy: As described in NEBB or AABC.
14. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 1. TAB Agency provides warranty for a period of 90 days following submission of completed report, during which time, Owner may request a recheck of up to 10 percent of total number of terminals, or resetting of outlet, coil, or device listed in the final TAB report.
 2. Guarantee: Meet the requirements of the following programs:
 - a. Provide a guarantee on NEBB or AABC forms stating that the agency will assist in completing the requirements of the Contract Documents if the TAB Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - (1) The certified Agent has tested, adjusted, and balanced systems according to the Contract Documents.
 - (2) Systems are balanced to optimum performance capabilities within design and installation limits.

1.7 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.
- C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- E. Report Forms: Test data sheets for recording test data in logical order.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- J. TAB: Testing, Adjusting, and Balancing.
- K. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- L. Test: A procedure to determine quantitative performance of a system or equipment.
- M. Testing, Adjusting, and Balancing (TAB) Agent: The entity responsible for performing and reporting the TAB procedures.
- N. AABC: Associated Air Balance Council.
- O. NEBB: National Environmental Balancing Bureau.
- P. AMCA: Air Movement and Control Association.
- Q. CTI: Cooling Tower Institute.
- R. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.8 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. Notice: Provide 7 days advance notice for each test. Include scheduled test dates and times.
- C. Witness leakage and pressure tests carried out by Section 23 31 00, HVAC Ducts and Casings.
- D. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS AND PROCEDURES

A. Project Conditions:

1. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire TAB period. Cooperate with the Owner during TAB operations to minimize conflicts with the Owner's operations.
2. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during TAB operations to minimize conflicts with the Owner's operations.
3. Non-Owner Occupancy: Complete balancing of building systems prior to Substantial Completion and owner occupancy.

B. General Requirements:

1. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and controls, coordinate scheduling and testing and inspection procedures with authorities having jurisdiction.
2. Perform TAB work with doors, closed windows, and ceilings installed etc., to obtain simulated or project operating conditions. Do not proceed until systems scheduled for TAB are clean and free from debris, dirt and discarded building materials.
3. Where Owner occupies building during the testing period, cooperate with Owner to minimize conflicts with Owner's operations.

C. Examination:

1. Examine Contract Documents to become familiar with project requirements and existing building record documents (if available) to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - a. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
 - b. Verify that balancing devices, such as test ports, gauge 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

TESTING, ADJUSTING, AND BALANCING FOR HVAC

system and equipment operation.

2. Examine approved submittal data of HVAC systems and equipment.
 3. Examine Project record documents described in Division 01, General Requirements.
 4. Examine Architect's and Engineer's design data, including Basis of Design, 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.
 5. 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 the 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, "Fans and Systems," 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.
 6. Coordinate requirements in system and equipment with this Section.
 7. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.
 8. Examine system and equipment test reports.
 9. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
 10. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
 11. Examine equipment for installation and for properly operating safety interlocks and controls.
 12. Report deficiencies discovered before and during performance of TAB procedures.
- D. Preparation:

TESTING, ADJUSTING, AND BALANCING FOR HVAC

1. Prepare a TAB plan that includes strategies and step-by-step procedures.
 2. Complete system readiness checks and prepare system readiness reports. Verify the following:
 - a. Permanent electrical power wiring is complete.
 - b. Hydronic systems are filled, clean, and free of air.
 - c. Automatic temperature-control systems are operational.
 - d. Equipment and duct access doors are securely closed.
 - e. Balance, smoke, and fire dampers are open.
 - f. Isolating and balancing valves are open and control valves are operational.
 - g. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - h. Windows, doors and other portions of the building envelope can be closed so design conditions for system operations can be met.
 3. Hold a pre-balancing meeting at least one week prior to starting TAB work.
 - a. Attendance is required by installers whose work will be tested, adjusted, or balanced.
 4. Provide instruments required for TAB operations. Make instruments available to Architect to facilitate spot checks during testing.
- E. General TAB Procedures:
1. Perform TAB procedures on each system according to the procedures contained in NEBB or AABC and this Section.
 2. Coordinate location of test probes prior to start of TAB procedures and make test probes available for Owner's tests after start of occupancy. Where required, 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 the insulation Specifications for this Project.
 3. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

F. Adjustment Tolerances:

1. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.
2. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
3. Hydronic Systems: Adjust to within plus or minus 10 percent of design at coils and plus or minus 5 percent at system pumps and equipment.
4. Adjust supply, return, and exhaust air quantities to maintain pressurization in spaces indicated on Drawings. Note and document room-to-room pressurization and maintain these relationships. Adjust pressure controlled spaces to within plus or minus 0.01 in WC.

G. Recording and Adjusting:

1. Field Logs: Maintain written logs including:
 - a. Running log of events and issues.
 - b. Discrepancies, deficient or uncompleted work by others.
 - c. Contract interpretation requests.
 - d. Lists of completed tests.
2. Ensure recorded data represents actual measured or observed conditions.
3. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
4. Mark on drawings locations where traverse and other critical measurements were taken and cross reference location in final report.
5. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
6. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
7. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by Owner's Authorized Representative, or Commissioning Agent.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

3.2 FUNDAMENTAL AIR SYSTEMS BALANCING PROCEDURES

- A. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- B. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.
- C. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- D. Prepare test reports for both fans and inlets and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan volumes.
- E. Prepare schematic diagrams of systems' "as-built" duct layouts.
- F. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- G. Check the airflow patterns from the outside-air louvers and dampers and the return-air and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- H. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- I. Verify that motor starters are equipped with thermal protection, sized for the connected load.
- J. Check dampers for proper position to achieve desired airflow path.
- K. Check for airflow blockages.
- L. Check that condensate drains are installed, trapped and primed and routed to drain.
- M. Check for readily observable leaks in air-handling unit components and ductwork.
- N. Use sheaves and pulleys to adjust the speed of belt drive fans to achieve design flow with motors running at 60 Hertz unless noted otherwise.

3.3 TEMPERATURE CONTROL VERIFICATION

- A. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices operate by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units,

TESTING, ADJUSTING, AND BALANCING FOR HVAC

mixing boxes, and variable-air-volume terminals.

4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, equipment, drafts, and cold walls.
 6. Sensors are located to sense only the intended conditions.
 7. Sequence of operation for control modes is according to the Contract Documents.
 8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
 9. Interlocked systems are operating.
 10. Changeover from heating to cooling mode occurs according to design values.
- B. Verify that controllers are calibrated and commissioned.
- C. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- D. Record controller settings and note variances between set points and actual measurements.
- E. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).
- F. Verify free travel and proper operation of control devices such as damper and valve operators.
- G. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.
- H. Confirm interaction of electrically operated switch transducers.
- I. Confirm interaction of interlock and lockout systems.
- J. Verify main control supply-air pressure and observe compressor and dryer operations.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.4 CONSTANT VOLUME AIR SYSTEMS BALANCING PROCEDURES

- A. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer. Adjust fans to deliver design airflow at the lowest possible speed.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
2. Measure static pressure across each air-handling unit component under final balanced condition.
3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Recommend corrective action to align design and actual conditions.
4. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
5. Do not make fan-speed adjustments that result in motor loading greater than full load amps. Do not increase fan speed beyond fan class rating. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.
6. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design airflows within specified tolerances.
7. Calibrate airflow measuring stations.

3.5 PRE-BALANCE REPORTING

A. Pre-Construction Phase Report:

1. Provide a pre-construction phase TAB Plan at least 2 weeks prior to the commencement of TAB work. This report is to include:
 - a. A complete set of report forms intended for use on the Project, with all data filled in except for the field readings. Forms to be Project-specific.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- b. Marked up shop drawings identifying all HVAC equipment to be balanced, and associated outlets and terminal devices.
 - c. Identification of the type, manufacturer, and model of actual instruments to be used, and clear indication of which instrument will be used to take each type of reading. Calibration certifications are to be included.
 - d. A narrative of Project-specific and/or non-standard TAB procedures to be used, and the equipment or systems they apply to.
- B. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- C. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced.

3.6 FINAL REPORTS

- A. Report Requirements:
- 1. General:
 - a. Computer generated in PDF format and tabulated, divided, and bookmarked into sections by tested and balanced systems.
 - b. Include a certification sheet in front of binder signed and sealed by the certified TAB engineer.
 - (1) Include a list of the instruments used for procedures, along with proof of calibration.
 - c. Final Report Contents: In addition to the certified field report data, include the following:
 - (1) Pump curves
 - (2) Fan Curves
 - (3) Manufacturers Test Data
 - (4) Field test reports prepared by system and equipment installers

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- (5) Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data

B. General Report Data:

1. In addition to the form titles and entries, include the following data in the final report, as applicable:
 - a. Title Page
 - b. Name and Address of TAB Agent
 - c. Project Name
 - d. Project Location
 - e. Architect's Name and Address
 - f. Engineer's Name and Address
 - g. Contractor's Name and Address
 - h. Report Date
 - i. Signature of TAB Agent who Certifies the Report
 - j. Summary of Contents, Including the Following:
 - (1) Design versus Final Performance
 - (2) Notable Characteristics of Systems
 - (3) Description of System Operation Sequence if it varies from the Contract Documents
 - k. Nomenclature Sheets for Each Item of Equipment
 - l. Data for Terminal Units, including Manufacturer, Type Size, and Fittings
 - m. Notes to explain why certain final data in the body of reports vary from design values.
 - n. Test Conditions for Fans and Pump Performance Forms, Including the Following:
 - (1) Settings for Outside-, Return-, and Exhaust-air Dampers
 - (2) Conditions of Filters
 - (3) Cooling Coil, Wet- and Dry-bulb Conditions

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- (4) Face and Bypass Damper Settings at Coils
 - (5) Fan Drive Settings, including Settings and Percentage of Maximum Pitch Diameter
 - (6) Inlet Vane Settings for Variable-Air-Volume Systems
 - (7) Settings for Supply-air, Static-pressure Controller
 - (8) Other System Operating Conditions that affect Performance
- C. System Diagrams:
1. Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
 - a. Quantities of Outside, Supply, Return, and Exhaust Airflows
 - b. Water and Steam Flow Rates
 - c. Duct, Outlet, and Inlet Sizes
 - d. Pipe and Valve Sizes and Locations
 - e. Terminal Units
 - f. Balancing Stations
- D. Air Handling Units:
1. For air-handling units, split systems, fan coils, pumps, and evaporator units with coils, include the following:
 - a. Unit Data: Include the following:
 - (1) Unit Identification
 - (2) Location
 - (3) Make and Type
 - (4) Model Number and Unit Size
 - (5) Manufacturer's Serial Number
 - (6) Unit Arrangement and Class
 - (7) Discharge Arrangement
 - (8) Sheave Make, Size in inches, and Bore

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- (9) Sheave Dimensions, Center-to-center and Amount of Adjustments in Inches
 - (10) Number of Belts, Make, and Size
 - (11) Number of Filters, Type, and Size
- b. Motor Data: Include the following:
- (1) Make and Frame Type and Size
 - (2) Horsepower and rpm
 - (3) Volts, Phase, and Hertz
 - (4) Full-load Amperage and Service Factor
 - (5) Sheave Make, Size in Inches, and Bore
 - (6) Sheave Dimensions, Center-to-center and Amount of Adjustments in Inches
- c. Test Data: Include design and actual values for the following:
- (1) Total Airflow Rate in cfm (L/s)
 - (2) Total System Static Pressure in Inches wg (Pa)
 - (3) Fan rpm
 - (4) Discharge Static Pressure in Inches wg (Pa)
 - (5) Filter Static-pressure Differential in Inches wg (Pa)
 - (6) Preheat Coil Static-pressure Differential in Inches wg (Pa)
 - (7) Cooling Coil Static-pressure Differential in Inches wg (Pa)
 - (8) Heating Coil Static-pressure Differential in Inches wg (Pa)
 - (9) Outside Airflow in cfm (L/s)
 - (10) Return Airflow in cfm (L/s)
 - (11) Outside-air Damper Position
 - (12) Return-air Damper Position
 - (13) Vortex Damper Position

TESTING, ADJUSTING, AND BALANCING FOR HVAC

E. Fans:

1. Fan Test Reports: For supply, return, and exhaust fans, include the following:

a. Fan Data: Include the following:

- (1) System Identification
- (2) Location
- (3) Make and Type
- (4) Model Number and Size
- (5) Manufacturer's Serial Number
- (6) Arrangement and Class
- (7) Sheave Make, Size in Inches, and Bore
- (8) Sheave Dimensions, Center-to-center and Amount of Adjustments in Inches

b. Motor Data: Include the following:

- (1) Make and Frame Type and Size
- (2) Horsepower and rpm
- (3) Volts, Phase, and Hertz
- (4) Full-load Amperage and Service Factor
- (5) Sheave Make, Size in Inches, and Bore
- (6) Sheave Dimensions, Center-to-center and Amount of Adjustments in Inches
- (7) Number of Belts, Make, and Size

c. Test Data: Include design and actual values for the following:

- (1) Total Airflow Rate in cfm
- (2) Total System Static Pressure in Inches wg
- (3) Fan rpm
- (4) Discharge Static Pressure in Inches wg

TESTING, ADJUSTING, AND BALANCING FOR HVAC

- (5) Suction Static Pressure in Inches wg

F. Duct Traverses:

1. Include a diagram with a grid representing the duct cross-section and record the following:
 - a. Report Data: Include the following:
 - (1) System and Air-handling Unit Number
 - (2) Location and Zone
 - (3) Duct Static Pressure in Inches wg
 - (4) Duct Size in Inches
 - (5) Duct Area in SF
 - (6) Design Airflow Rate in cfm
 - (7) Design Velocity in fpm
 - (8) Actual Airflow Rate in cfm
 - (9) Actual Average Velocity in fpm

G. Diffusers/Registers/Grilles:

1. For diffusers, registers and grilles, include the following:
 - a. Unit Data: Include the following:
 - (1) System and Air-handling Unit Identification
 - (2) Location and Zone
 - (3) Test Apparatus Used
 - (4) Area Served
 - (5) Air-terminal-device Make
 - (6) Air-terminal-device Number from System Diagram
 - (7) Air-terminal-device Type and Model Number
 - (8) Air-terminal-device Size
 - (9) Air-terminal-device Effective Area in SF

TESTING, ADJUSTING, AND BALANCING FOR HVAC

b. Test Data: Include design and actual values for the following:

- (1) Airflow Rate in cfm
- (2) Air Velocity in fpm
- (3) Final Airflow Rate in cfm
- (4) Final Velocity in fpm
- (5) Space Temperature in Degrees F

H. Instrument Calibration:

1. For instrument calibration, include the following:

a. Report Data: Include the following:

- (1) Instrument Type and Make
- (2) Serial Number
- (3) Application
- (4) Dates of Use

b. Dates of Calibration

3.7 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 inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION

This page intentionally left blank

HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Type A, Flexible Glass Wool Blanket
2. Type B, Duct Liner
3. Type 2, Flexible Elastomeric Pipe Insulation
4. Jacketing
5. Accessories
6. Duct Insulation Accessories
7. Duct Insulation Compounds

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
1. Installer qualifications.
 2. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any) for each type of product indicated.
 - a. Where indicated R-values/ratings cannot be achieved by a single layer of insulation, describe how performance requirements will be achieved.
 3. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

HVAC INSULATION

4. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.
5. Submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 1. Formaldehyde Free: Should be third-party certified with UL Environment Validation.
 2. Recycled Content: A minimum of 40 percent post-consumer recycled glass content certified and UL validated.
 3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation products, provide materials complying with the testing and products requirements of UL GREENGUARD Gold Certification.
 4. Installer to have minimum 5 years' experience in the business of installing insulation.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 FIRE HAZARD CLASSIFICATION

- A. Maximum fire hazard classification of the composite insulation construction as installed to be not more than a Flame Spread Index (FSI) of 25 and Smoke Developed Index (SDI) of 50 as tested by current edition of ASTM E84 (NFPA 255) method.
- B. Test pipe insulation in accordance with the requirements of current edition of UL "Pipe and Equipment Coverings R5583 400 8.15."
- C. Test duct insulation in accordance with current edition of ASTM E84, UL 723, NFPA 255, NFPA 90A and NFPA 90B.

PART 2 - PRODUCTS

2.1 TYPE A, FLEXIBLE GLASS WOOL BLANKET

- A. Acceptable Manufacturers:
 1. Certainteed

HVAC INSULATION

2. Johns Manville
 3. Knauf
 4. Owens-Corning
- B. ASTM C553, Type 1, Class B-2; flexible blanket.
- C. 'K' Value: 0.27 BTU*in/(hr*sf*F) at 75 degrees F installed, maximum service temperature: 250 degrees F.
- D. Density: 0.75 pounds per cubic foot.
- E. DBDE-free. UL/E validated to be formaldehyde-free.
- F. Vapor Barrier Jacket: FSK aluminum foil reinforced with glass wool yarn and laminated to fire resistant Kraft, secured with UL listed pressure sensitive tape or outward clinched expanded staples and vapor barrier mastic as needed.

2.2 TYPE B, DUCT LINER

- A. Acceptable Manufacturers:
1. Certainteed
 2. Johns Manville
 3. Knauf
 4. Owens-Corning
- B. ASTM C1071; flexible blanket.
- C. 'K' Value: ASTM C518, 0.25 BTU*in/(hr*sf*F) at 75 degrees F, maximum service temperature: 250 degrees F.
- D. Noise Reduction Coefficient: 0.65 or higher based on ASTM C 423 "Type A mounting."
- E. Maximum Velocity on Mat or Coated Air Side: 5,000 FPM.
- F. Adhesive: UL listed waterproof type.
- G. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
- H. Erosion-Resistant Surfaces: UL 181.
- I. ASTM G21 and ASTM G22 Microbial Growth Resistance.
- J. UL GREENGUARD Certified does not support the growth of mold, fungi, or bacteria per ASTM C 1338 and meets UL Environment GREENGUARD Microbial Resistance

HVAC INSULATION

Listing per UL 2824-“GREENGUARD Certification Program Method for Measuring Microbial Resistance.” DBDE-free. UL/E validated to be formaldehyde-free.

2.3 TYPE 2, FLEXIBLE ELASTOMERIC PIPE INSULATION

A. Acceptable Manufacturers:

1. Insulation:

- a. Armacell LLC Armaflex
- b. K-Flex
- c. Or approved equivalent.

2. Glue:

- a. Armacell LLC Armaflex Low VOC Adhesive
- b. K-Flex
- c. Or approved equivalent.

3. Paint:

- a. Armacell LLC Armaflex
- b. K-Flex
- c. Or approved equivalent.

B. Elastomeric Foam: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. Thermal Conductivity Value: As indicated in the insulation tables below.
2. Maximum Service Temperature of 220 degrees F.
3. Maximum Flame Spread: 25.
4. Maximum Smoke Developed: 50 (1-inch thick and below).
5. Vapor Retarder Jacket, for over 1-inch insulation thickness: White Kraft paper reinforced with glass wool and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips or vapor barrier mastic.
6. Connection: Waterproof vapor retarder adhesive as needed.
7. UV Protection: UV outdoor protective coating per manufacturer's requirements.

HVAC INSULATION

- C. Glue: Contact adhesive specifically manufactured for cementing flexible elastomeric foam.
- D. Paint (for exterior insulation only): Nonhardening high elasticity type, specifically manufactured as protective covering of flexible elastomeric foam insulation for prevention of degradation due to exposure to sunlight and weather.

2.4 JACKETING

- A. Acceptable Manufacturers:
 - 1. ITW Insulation Systems
 - 2. General Insulation Company
 - 3. Johns Manville
 - 4. 3M
 - 5. Or approved equivalent.
- B. Insulation Jacketing Tape: 0.016-inch thick multi-layered laminate with minimum tensile strength of 149-lb/inch, minimum puncture resistance of 49 pounds per ASTM D1000, maximum emittance of 0.03 per ASTM C1371, maximum WVTR of 0.00 perm per ASTM E96, and min/max service temperature of -40 degrees F to 300 degrees F, as manufactured by 3M, VentureClad1579GCW-E.
- C. PVC preformed molded insulation covers, for piping. Zeston or approved equivalent.

2.5 ACCESSORIES

- A. Acceptable Manufacturers:
 - 1. ITW Insulation Systems
 - 2. Or approved equivalent.
- B. Equipment Insulation Jacketing: Presized glass cloth, not less than 7.8 ounces/sq.yd., except as otherwise indicated. Coat with gypsum based cement.
- C. Equipment Insulation Compounds: Provide adhesives, cement, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
- D. General: Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers as recommended by insulation manufacturer for applications indicated. Accessories, i.e., adhesives, mastics, cements and tape to have the same flame and smoke component ratings as the insulation materials with which they are used. Shipping cartons

HVAC INSULATION

to bear a label indicating that flame and smoke ratings do not exceed those listed above. Provide permanent treatment of jackets or facings to impart flame and smoke safety. Provide non-water-soluble treatments. Provide UV protection recommended by manufacturer for outdoor installation.

2.6 DUCT INSULATION ACCESSORIES

- A. Acceptable Manufacturers:
 - 1. Certainteed
 - 2. Johns Manville
 - 3. Owens-Corning
- B. Staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

2.7 DUCT INSULATION COMPOUNDS

- A. Acceptable Manufacturers:
 - 1. Certainteed
 - 2. Johns Manville
 - 3. Owens-Corning
- B. Cements, adhesives, coatings, sealers, protective finishes and similar accessories as recommended by insulation manufacturer for applications indicated. Comply with South Coast Air Quality Management District (SCAQMD) Rule #1168 in accordance with LLE EQ 4.1.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Verification of Conditions:
 - 1. Do not apply insulation until pressure testing and inspection of ducts and piping has been completed.
 - 2. Examine areas and conditions under which duct and pipe insulation will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Preparation: Clean and dry surfaces to be insulated.
- C. Installation:

HVAC INSULATION

1. Insulation: Continuous through walls, floors and partitions except where noted otherwise.
2. Piping and Equipment:
 - a. Install insulation over clean, dry surfaces with adjoining sections firmly butted together and covering surfaces. Fill voids and holes. Seal raw edges. Install insulation in a manner such that insulation may be split, removed, and reinstalled with vapor barrier tape on strainer caps and unions. Do not install insulation until piping has been leak tested and has passed such tests. Do not insulate manholes, equipment manufacturer's nameplates, handholes, and ASME stamps. Provide beveled edge at such insulation interruptions. Repair voids or tears.
- D. Cover insulation on exposed refrigerant piping above ground, outside of building with heavy duty multi-layered laminated jacketing tape. Position seams on bottom of pipe. Use 3M VentureClad Plus 1579GCW-E or approved equal.
- E. Provide accessories as required. See Part 2 Article "Accessories" above.
- F. Protection and Replacement: Installed insulation during construction. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- G. Labeling and Marking: Provide labels, arrows and color on piping and ductwork. Attach labels and flow direction arrows to the jacketing per Section 23 05 53, Identification for HVAC Piping, Ductwork and Equipment.
- H. Ductwork:
 1. Install insulation in conformance with manufacturer's recommendations to completely cover duct.
 2. Butt insulation joints firmly together and install jackets and tapes smoothly and securely.
 3. Apply duct insulation continuously through sleeves and prepared openings, except as otherwise specified. Apply vapor barrier materials to form complete unbroken vapor seal over insulation.
 4. Coat staples and seals with vapor barrier coating.
 5. Cover breaks in jacket materials with patches of same material as vapor barrier. Extend patches not less than 3-inches beyond break or penetration on all directions and secure with adhesive and staples. Seal staples and joints with vapor barrier coating.

HVAC INSULATION

6. Fill jacket penetrations. i.e., hangers, thermometers and damper operating rods, and other voids in insulation with vapor barrier coating. Seal penetration with vapor barrier coating. Insulate hangers and supports for cold duct in un-conditioned spaces to extent to prevent condensation on surfaces.
 7. Seal and flash insulation terminations and pin punctures with reinforced vapor barrier coating.
 8. Continue insulation at fire dampers and fire/smoke dampers up to and including those portions of damper frame visible at outside of the rated fire barrier. Insulating terminations at fire dampers in accordance with this Section.
 9. Do not conceal duct access doors with insulation. Install insulation terminations at access door in accordance with this Section.
- I. Insulated Pipe Exposed to Weather: Where piping is exposed to weather, cover insulation with PVC jacketing. Seal jacketing watertight per manufacturer's recommendations. Install metal jacketing with 2-inch overlap at longitudinal and butt joints with exposed lap pointing down. Secure jacketing with stainless-steel draw bands 12-inches on center and at butt joints.
- J. Insulation Shields: Provide hangers and shields (18 gauge minimum) outside of insulation for cold piping (<60 degrees F). Hot water piping hangers may penetrate insulation to contact pipe directly. Provide 18-inch long, noncompressible insulation section at insulation shields for lines 2-inches and larger (hot and cold) piping.
- K. Ductwork Surfaces to be Insulated: Climate Zone 4

Item to be Insulated	System Insulation Type	Duct Size	Minimum Installed R-Value
Supply ductwork inside building thermal envelope, where duct is not specified to be lined	A	All	R-6
Return ductwork inside building thermal envelope, where duct is not specified to be lined	--	All	None
Supply and return ductwork located outside building thermal envelope	A (for round ductwork)	All	R-8

HVAC INSULATION

(exposed to weather, above insulated ceilings, in crawl spaces, in parking garages)			
Outside air ducts inside building thermal envelope and upstream of automatic shutoff damper	A		R-16
Outside air ducts inside building thermal envelope and downstream of automatic shutoff damper	A		R-8
Exhaust ducts within building thermal envelope, between energy recovery media, and automatic shutoff damper	A	All	R-8
Exhaust ducts within building thermal envelope between exterior and automatic shutoff damper	A	All	R-16

- Note: Insulation R-value shown is a minimum. If state codes require higher R-value, then provide insulation per code requirements.

L. Piping Surfaces to be Insulated:

Item to be Insulated	System Insulation Type	Conductivity Range (Btu-inch per hour per SF per degrees F)	Pipe Size (Inches)	Insulation Thickness (Inches)
Refrigerant Suction and Liquid Piping	2	0.21-0.27 at a mean rating temperature	<1 1 to <1.5	0.5 0.5

HVAC INSULATION

(40F to 60F)		of 75 degrees F	1.5 to <4	1.0
			4 to <8	1.0
			>= 8	1.0
Refrigerant Suction and Liquid Piping (<=40F)	2	0.20-0.26 at a mean rating temperature of 50 degrees F	<1	0.5
			1 to <1.5	1.0
			1.5 to <4	1.0
			4 to <8	1.0
			>= 8	1.5

1. Note: Insulation thickness shown is a minimum. If state code requires additional thickness, then provide insulation thickness per code requirements.

3.2 TYPE A, FLEXIBLE GLASS WOOL BLANKET

- A. Install insulation in conformance with manufacturer's recommendations and requirements.
- B. Duct Wrap: Cover air ducts per insulation table except ducts internally lined where internal duct lining is adequate to achieve adequate insulating values to meet local Energy Codes (indicate on shop drawings, locations where duct wrap is planned to be omitted and indicate internal duct lining insulating values to confirm they will meet the Energy Code). Wrap tightly with circumferential joints butted and longitudinal joints overlapped minimum of 2-inches. On ducts over 24-inches wide, additionally secure insulation with suitable mechanical fasteners at 18-inches on center. Circumferential and longitudinal joints stapled with flare staples 6-inches on center and covered with 3-inch wide, foil reinforced tape.

3.3 TYPE B, DUCT LINER

- A. Install insulation in conformance with manufacturer's recommendations and requirements.
- B. Duct Liners: Mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous (minimum 90) percent coat of adhesive. Secure liner with mechanical fasteners 15-inches on center or per manufacturer requirements. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation overlap sides. Factory/field coat exposed edges. Metal nosing for exposed leading or transverse edges and when velocity exceeds 3500 FPM or manufacturer rating on exposed edges. Keep duct liner clean and free from dust. At

HVAC INSULATION

completion of Project, vacuum duct liner if it is dirty or dusty. Do not use small pieces. If insulation is installed without horizontal, longitudinal, and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.

3.4 TYPE 2, FLEXIBLE ELASTOMERIC PIPE INSULATION

- A. Flexible Elastomeric Insulation:
 - 1. Slip insulation on pipe prior to connection. Butt joints sealed with manufacturer's adhesive. Insulate fitting with miter-cut pieces. Cover insulation exposed to weather and below grade with two coats of finish as recommended by manufacturer.
- B. Flexible Elastomeric Tubing:
 - 1. Flexible Elastomeric Tubing: Slip insulation over piping or, if piping is already installed, slit insulation and snap over piping. Joints and butt ends must be adhered with 520 adhesive.
- C. See General Installation Requirements above.
- D. Install insulation in conformance with manufacturer's recommendations and requirements.
- E. Slip insulation on pipe prior to connection. Butt joints sealed with manufacturer's adhesive. Insulate fitting with miter-cut pieces. Cover insulation exposed to weather and undergrade with two coats of finish as recommended by manufacturer.
- F. Install in accordance with manufacturer's instructions for below grade installation.

3.5 JACKETING

- A. See General Installation Requirements above.
- B. Install in accordance with manufacturer's instructions.

3.6 ACCESSORIES

- A. Install insulation in conformance with manufacturer's instructions, recommendations and requirements.
- B. See General Installation Requirements above.
- C. Furnish and install accessories for all insulation types listed in this Section.

HVAC INSULATION

3.7 DUCT INSULATION ACCESSORIES

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

3.8 DUCT INSULATION COMPOUNDS

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

END OF SECTION

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Communications
2. Operator Interface
3. Controller Software
4. BAS Graphics
5. Building Controllers
6. Application Specific Controllers
7. Input/Output Interface
8. Power Supplies and Line Filtering
9. Control Panels
10. Auxiliary Control Devices
11. Wiring and Raceways
12. Smoke Detection for Projects with a Building Fire Alarm System

B. This is a performance specification and Contractor is responsible for design tasks and engineering.

1.2 RELATED SECTIONS

A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:

1. Current edition of ANSI/ASHRAE Standard 135 and addendum, BACnet.
2. Current edition of UL 916 Underwriters Laboratories Standard for Energy Management Equipment, Canada and the US.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

3. Current edition of FCC Part 15, Subpart J, Class A.
4. Current edition of BACnet Testing Laboratories (BTL).

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 1. Prepare and submit a detailed schedule of work. Schedule to identify milestones such as equipment submittals, control panel diagrams, color graphic panel displays, Interlock.
 2. Wiring diagrams, control program sequence software flow chart diagrams, conduit layout diagrams, device location diagrams, equipment and component deliveries, installation sequencing, controller startup, point to point startup, control programming, sequence testing, commissioning/acceptance testing and training.
 3. Submit design drawings, sequences of operation, program listings, software flow charts and details for each typical piece of equipment and system being controlled. No work to be initiated or fabrication of any equipment started prior to the Owner's Authorized Representatives return of REVIEWED submittals.
 - a. Sequence of Operation: The sequence of operation included in the design documents is intended only to communicate the Engineers' general control intent and is not to be used as a direct reference for programming of the EMS system. Verbatim duplication of the Engineer's Sequence of Operation on the submittals is discouraged and may result in non-approval of the submittal. Sequence of operation on submittals to accurately detail the system's intended programming, and include details of enhancements, adjustments, or deviations from the Engineer's sequence of operation. Submitted sequence of operation to be written with a logical and organized format and flow. Provide detailed, clear and unambiguous sequence of operation language. Point descriptors and point nomenclature referenced in the submitted sequence of operation to match those (to be) actually programmed. As-built submittal Sequence of Operation to include modifications to the programming made as a result of any addendum, bulletins, RFI's, change orders, and commissioning.
 4. Format: Make each submittal in one complete and contiguous package. Partial or unmarked submittals will be rejected without review.
 5. Submit Manufacturers Data as Follows:

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- a. Complete materials list of items proposed to be furnished and installed. A complete Bill of Materials, listing materials, components, devices, wire and equipment are required for this work. The Bill of Materials to be separate for each controller on its own page(s) and to contain the following information for each item listed:
 - (1) Manufacturer's Name and Model number with furnished options highlighted.
 - (2) Quantity of each by controller location.
 - (3) Description of product (generic).
 - (4) Specified item.
 - (5) Operating range or span.
 - (6) Operating point or setpoint.
- b. Manufacturer's specifications and other data required demonstrating compliance with the specified requirements, including but not limited to: Catalog cuts, technical data and descriptive literature on hardware, software, and system components to be furnished.
- c. The data to be clearly marked and noted to identify specific ranges, model numbers, sizes, and other pertinent data. Submit printed manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials and including printed installation instructions and start-up instructions.
- d. Unless specifically called for otherwise, provide bound copies of catalog cuts for standard products, not requiring specifically prepared Shop Drawings, for the following:
 - (1) Wire and Cable, Class II
 - (2) Face Plates for Devices
 - (3) Disconnect Switches for Power Control
- e. Where more than one item, size, rating or other variations appear on a catalog cut sheet, clearly identify items to be provided. These items to be properly indexed and referenced to identification numbers, designations and/or details on the Drawings.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

6. Shop Drawings: Submit shop drawings for each controlled system, depicting the following information:
 - a. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves and other control/monitoring devices.
 - b. Label each control device with initial setting or adjustable range of control. Label points in schematic diagrams with termination at corresponding controller.
 - c. Electrical Wiring: Clearly differentiate between portions of wiring that are factory installed and portions of be field-installed.
 - d. Details of control panel faces, including controls, instruments, and labeling.
 - e. Interfaces to equipment furnished under other Specification Sections identifying numbers of wires, termination location, voltages and pertinent details. Responsibility for each end of the interfaces to be noted on these drawings whether or not they are a part of this Section.
 - f. System architecture diagram showing the global connectivity of new controllers and any existing systems that will be connected to.
7. Equipment locations, wiring and piping schematics, details, panel configurations, sizes, damper motor mounting details, valve schedules, and a points list keyed to specific hardware submittals. Control wiring depicted as fully annotated ladder diagrams with terminations identified, completely configured as to the exact panel, wiring, relay, switch, and component configuration.
8. Tag Number Lists: Develop instruments tag number system and submit list for approval. Coordinate methods and number block with the Owner's Authorized Representative.
9. Format the Shop and Field Drawings to Include:
 - a. A Title Sheet containing a drawing list, abbreviations list, symbols list, site and vicinity maps for project location and schedules.
 - b. Floor Plans showing proposed device locations and device nomenclatures.
 - c. A Riser Diagram illustrating conduit relationships between devices shown on the Floor Plans. Show device nomenclatures.
 - d. A Single-Line Diagram for each system showing signal relationships of devices within the system. Show device nomenclatures.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- e. A Wiring Diagram for each assembly, enclosure or free standing device, showing:
 - (1) The Devices Within
 - (2) Wiring Connections
 - (3) Wire Identification
 - (4) Voltage Levels
 - (5) Fuse Ratings

- f. Operations and Maintenance Manuals:
 - (1) Following approval of Shop Drawings of control equipment and prior to acceptance of control work, prepare Operating and Maintenance manuals describing operating, servicing, and maintenance requirements of control systems and equipment installed under this Section, in accordance the General and Special Conditions of these Specifications.
 - (2) Information contained in the manual for the above equipment to include the following:
 - (a) Manufacturer's catalog cuts and printed descriptive bulletins.
 - (b) Manufacturer's installation, operating, and maintenance instruction booklets. Complete instructions regarding the operation and maintenance of equipment involved.
 - (c) Instrument calibration certificates.
 - (d) Parts list and costs.
 - (e) Complete nomenclature of replaceable parts, list of recommended spare parts for 12 months operation, their part numbers, current cost and name and address of the nearest vendor of replacement parts.
 - (f) Name, address and telephone number for closest source of spare parts.
 - (g) Wiring and schematic diagrams.
 - (h) Include final record copies of shop drawings.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- (i) Copy of guarantees and warranties issued for the various items of equipment, showing dates of expiration.
 - (j) Reduced plans, diagrams, and control schematics.
 - (k) Copies of test results.
 - (l) Control System Operating Manual including: point of summary and point data base; complete printout of program listings; magnetic tape CD or DVD backup of Field Control Cabinet programs; cabinet layout; hard copy of graphic screens; hard copy of specified reports.
- g. A final Bill of Quantities including a separate schedule for portable equipment, if delivered as part of this work.
 - h. Performance, Test and Adjustment Data: Comprehensive documentation of performance verification according to parameters specified in these specifications.
 - i. Record Drawings: Comply with Division 01, General Requirements and Section 23 00 00, HVAC Basic Requirements. Provide complete as-built submittals including "as-programmed" sequence of operation as well as final occupancy schedules.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Installer Qualifications: Company specializing in performing work of the type specified in this Section with minimum five years' experience in the local area. Installers required to have successfully completed manufacturer's control system factory training.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 SYSTEM DESCRIPTION

- A. Control system referenced throughout specifications and drawings as Building Automation System (BAS), Building Management System (BMS), or Energy Management System (EMS) interchangeably consists of high-speed, peer-to-peer

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

network of DDC controllers, control system server, and operator workstation.

- B. Control software added under this effort is to meet the standards of the existing system. Intent is to provide operators complete access to control system. No special software other than web browser required to access graphics, point displays, and trends.
- C. System will consist of open architecture that is capable of:
 - 1. High speed Ethernet communication using TCP/IP protocol.
 - 2. Native BACnet communications according to ANSI / ASHRAE Standard 135, latest edition. Provide necessary BACnet-compliant hardware and software to meet the system's functional specifications. Controller devices must be BTL tested and listed by an official BACnet Testing Laboratory and have the BTL mark issued.
- D. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation valves and dampers.
- E. Prepare individual hardware layouts, interconnection drawings, building riser/architecture diagram and sequence of control from the project design data. Any architecture diagrams on design drawings have been included as schematics only and are not meant to portray quantity of devices or power/data requirements.
- F. Design, furnish, and install equipment cabinets, panels, data communication network infrastructure (including cables, conduits, outlets, connections, etc.) needed, and associated hardware.
- G. Provide complete manufacturer's specifications for items that are supplied. Include vendor name and model number of every item supplied.
- H. Provide a comprehensive operator and technician training program as described in these Specifications.
- I. Provide as-built documentation, operator's terminal software, diagrams, and other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.
- J. Provide 120V power, low voltage power, transformers, etc. for control panels, transformer panels, and BAS devices. Install per Division 26, Electrical Specifications. Power for devices within this Specification Section is solely the responsibility of the BAS Contractor.
- K. Conduit and raceway systems. Provide per Division 26, Electrical Specifications.
- L. Devices, components, controllers, and software to be manufacturer's most current version at the time of installation.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

1.8 SYSTEM PERFORMANCE

- A. Performance Standards - Conform to the existing BAS system performance standards over network connections.
 - 1. Alarm Response Time: Object that goes into alarm is annunciated at workstation within 45 seconds.
- B. Reporting Accuracy: System reports values with minimum end-to-end accuracy listed in Reporting Accuracy Table below.

1. Reporting Accuracy Table:

Measure Variable	Reported Accuracy
Space Temperature	Plus or Minus 1 degree F
Ducted Air	Plus or Minus 1 degrees F
Outside Air	Plus or Minus 2 degrees F
Dew Point	Plus or Minus 3 degrees F
Water Temperature	Plus or Minus 1 degree F
Delta-T	Plus or Minus 0.25 degree F
Relative Humidity	Plus or Minus 5 percent RH
Water Flow	Plus or Minus 2 percent of full scale

- 2. Note 1: Accuracy applies to 10 percent-100 percent of scale
- 3. Note 2: For both absolute and differential pressure
- 4. Note 3: Not including utility-supplied meters

- C. Control Stability and Accuracy. Control loops maintain measured variable at setpoint within tolerances listed in Control Stability and Accuracy Table below.

1. Control Stability and Accuracy Table:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	Plus or minus 0.2 inch wg	0-6 inch wg
	Plus or minus 0.01 inch wg	-0.1 to 0.1 inch wg
Airflow	Plus or minus 10 percent of full scale	
Space Temperature	Plus or minus 2.00 degrees F	
Duct Temperature	Plus or minus 3.0 degrees F	
Humidity	Plus or minus 5 percent RH	
Fluid Pressure	Plus or minus 1.5 PSI	1-150 PSI

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

	Plus or minus 1.0 inch wg	0-50 inch wg differential
--	------------------------------	------------------------------

PART 2 - PRODUCTS

2.1 OREGON/WASHINGTON MANUFACTURERS

- A. Delta Controls (Base Bid)
- B. Duct/Spot-Type Smoke Detectors (Project with Fire Alarm System):
 - 1. See Division 28 for Products.

2.2 COMMUNICATIONS

- A. Each controller to have communication port for connection to existing operator interface.
 - 1. Internetwork operator interface and value passing to be transparent to internetwork architecture.
 - 2. Operator interface connected to controller to allow operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs to be viewable and editable from each internetwork controller.
- B. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers to be readable by each controller on internetwork.
- C. Building Control Panels and Controllers with real-time clocks use time synchronization service. System automatically synchronizes system clocks daily from operator-designated device via internetwork. System automatically adjusts for daylight savings and standard time as applicable.

2.3 OPERATOR INTERFACE

- A. Interfaces to Third Party Systems: BAS connects to third party systems (VFDs, chillers, emergency generators, rooftop AC units, etc.). Communication protocol specified for third party system, and BAS provides compatible protocol to assure proper two way communication. Points, alarms, and commands displayed on BAS as indicated.

2.4 CONTROLLER SOFTWARE

- A. Furnish following applications software for integrating into existing building and energy management. Software applications reside and operate in system controllers. Software to be manufacturer's most current version at the time of installation. Software and associated functions (scheduling, optimum start/stop, etc.) noted in this specification are to be configured and enabled for this project. Incorporate into sequence of operation submittals for review prior to installation.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- B. System Security:
1. User access secured using individual security passwords and user names.
 2. Record user Log On/Log Off attempts.
 3. Provide passwords, user names, and access assignments adjustable at the operator's terminal. Each user to have a set security level, which defines access to displays and individual objects the user may control. System to include 10 separate and distinct security levels for assignment to users.
 4. System to include an Auto Logout Feature that will automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period to be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal to display message on screen that user is logged out after Auto Logout occurs.
- C. Scheduling: Provide capability to schedule each object or group of objects in system. Coordinate schedule with Owner and program accordingly. Each schedule consists of:
1. Operator's workstation to show information in easy-to-read daily format. Priority for scheduling: Events, holidays and daily with events being the highest.
 2. Holiday and special event schedules to display data in calendar format. Operator able to schedule holidays and special events directly from these calendars.
 3. Operator able to change information for a given weekly or exception schedule if logged on with the appropriate security access.
- D. Optimum Start/Stop: Provide software and program system to start equipment on sliding schedule based upon indoor and outdoor conditions. Determine minimum time of HVAC system operation needed to satisfy space environmental requirements and also determine earliest possible time to stop mechanical systems (i.e. shut down cooling/heating and only provide ventilation one hour prior to scheduled unoccupied period.). Optimum start/stop program operates in conjunction with scheduled start/stop and night setback programs.
- E. Alarms:
1. Operator's workstation to provide visual means of alarm indication. The alarm dialog box to always become the top dialog box regardless of the application(s), currently running.
 2. System to provide log of alarm messages. Alarm log to be archived to the hard disk of the system operator's terminal. Each entry to include a description of the event-initiating object generating the alarm. Entry to include time and date of alarm occurrence.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

3. Alarm messages in user-definable text and entered either at the operator's terminal or via remote communication.
4. Each binary object set to alarm based on operator-specified state.
5. Each analog object have both high and low alarm limits.
6. Alarms must be able to be automatically and manually disabled.
7. Alarms are routed to appropriate workstations based on time and other conditions. An alarm is able to start programs, print, be logged in event log, generate custom messages, and display graphics.
8. System have ability to dial out in event of alarm.
9. Alarm Levels:
 - a. Provide 5 levels of alarm as follows, and program alarm levels for every required and specified alarm:
 - (1) Level 1: Critical/life safety.
 - (2) Level 2: Significant equipment failure.
 - (3) Level 3: Non-critical equipment failure/operation.
 - (4) Level 4: Energy conservation monitor.
 - (5) Level 5: Maintenance indication, notification.
 - b. Prior to training of Owner's Authorized Representative, submit the complete Points List and suggested Alarm Levels to the Owner.
 - c. During training of Owner's Authorized Representative(s):
 - (1) Discuss Alarm Levels and the alarms currently included in the BAS.
 - (2) Provide additional alarms without addition of new hardware points, as required by Owner's Authorized Representative.
 - (3) Agree with the Owner's Authorized Representative on action(s) to be taken for each alarm level and implement same for each alarm. Said action to include visual and/or audible alarm(s) at the Operator workstation including whether Operator acknowledgement is required or not, email messages, and text messages.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- F. Maintenance Management: System monitors equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits. Coordinate settings with Owner.
- G. Sequencing: Provide application software based upon sequences of operation specified to properly sequence designated systems. Provide points to achieve specified sequences.
- H. Staggered Start: This application prevents controlled equipment from simultaneously restarting after a power outage. Order in which equipment (or groups of equipment) is started, along with time delay between starts to be user-selectable.
- I. Energy Calculations: Provide software to allow instantaneous power (e.g. kW) or flow rates (e.g. L/s (gpm)) to be accumulated and converted to energy usage data.
- J. Anti-Short Cycling: Binary output objects protected from short cycling by allowing minimum on-time and off-time to be selected.
- K. On/Off Control with Differential: Provide algorithm that allows binary output to be cycled based on controlled variable and setpoint. Algorithm direct-acting or reverse-acting and incorporate adjustable differential.
- L. Run-Time Totalization: Provide software to totalize run-times for binary input objects.

2.5 BAS GRAPHICS

- A. Replicate graphics to match the existing BAS graphics.
- B. Develop customized graphics showing the project building(s) and their floor plans, mechanical, and electrical equipment, flow and control diagrams, and other relevant features on Workstation graphic screens. Associated input, output, and virtual objects (e.g., temperature and pressure setpoints) listed in the Sequence of Operation, and shown on the Input/Output Objects List included in the graphic screens and bound to the database. Real-time value of objects updated on the display of each graphic automatically.
- C. Alarms: System and component summary alarms located near the top of each relevant graphic screen. Provide links to the associated system/component as part of these tags to assist trouble shooting. Other alarms placed near the associated system/device as depicted in the graphic. Provide text and color of information tags that describe each object and alarm value consistent with a graphics color legend.
- D. The Following Graphics Provided as a Minimum:
 - 1. A building graphic, typically a photograph of the building, with links to each floor plan and other links as defined below.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

2. Central equipment such as air handler, package rooftop equipment, supply fans, exhaust fans, and smoke control systems.
 3. Floor plans of each floor, with temperature sensors, pressure sensors, temperature control zones, heating/cooling zones, ventilation zones, and supply air zones identified. Rooms grouped on a graphic only to the extent that detailed and complete sensing information can be comfortably viewed by an operator and the bound points updated in less than 10 seconds. Each zone to have a temperature symbol that changes color over the range from low (blue) through normal (green) to high (red) and indicate an alarm (flashing red). The zone temperature and or pressure symbol(s) to be a link to a zone control pop-up graphic. Individual floor plan graphics to provide links to related mechanical systems. The mechanical room plan graphics to show the relative location of, and provide links to, either the equipment pop-up or flow and control graphic for mechanical equipment monitored or controlled by the BAS.
 4. Pop-up graphics provided for each zone control system showing a flow diagram and related monitoring and control points and system parameters. Pop-up graphics provided for each piece of equipment that is not shown on a flow and control graphic.
 5. Individual equipment/component screens showing sensing and control information available for each device provided.
- E. Clutter Minimization: Each graphic to have separate check boxes in the lower right corner that show/hide setpoints, alarms/safeties, and devices/equipment.
- F. Templates: To the maximum extent possible, use standard graphics as templates to provide a consistent look throughout the interface.
- G. Color Scheme: The graphics to use dynamic color changes to communicate equipment type, or object status consistent with the graphics color legend.
- H. Symbols and Animations: Fans, pumps, dampers, coils, and generation equipment to be dynamic symbols indicating rotation, state, or position, movement, flow, etc.
- I. Macros: When macros are used to add functionality to the graphics, detailed documentation provided.
- J. Configure Mode: Access to “Configure Mode” for editing of the graphics password protected to prevent unauthorized changes to the graphics. This password supplied to the appropriate personnel.
- K. Graphics Version: Graphics provided in the most current format available at time of control system programming.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- L. Points and graphics checked for the proper binding and graphic programming, settings to ensure that the correct system, location, point values and dynamics are shown in the proper location and rotate in the proper directions.
- M. After graphics have been accepted, provide, on a CD ROM in an agreed upon file structure. If the graphics have active-x controls or other files that must be placed outside the graphics folder structure a set-up program provided on the disk to place the files in the correct locations.

2.6 BUILDING CONTROLLERS

- A. General: Provide adequate number of building controllers to achieve performance specified. Panels to meet the following requirements.
 - 1. Building Automation System (BAS) to be composed of one or more independent, stand-alone, microprocessor-based building controllers to manage global strategies described in Controller Software article.
 - 2. Provide sufficient memory to support operating system, database, and programming requirements.
 - 3. Share data between networked building controllers.
 - 4. Distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
 - 5. Controllers that perform scheduling have real-time clock.
 - 6. Continually check status of its processor and memory circuits and if abnormal operation is detected, controller:
 - a. Assume predetermined failure mode.
 - b. Generate alarm notification.
 - 7. Building Controller communicates with other devices on internetwork including BACnet communications according to specified protocol.
- B. Communication:
 - 1. Each building controller resides on network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and performs routing to network of custom application and application specific controllers.
 - 2. Controller provides a service communication port for connection to a portable operator's terminal.
- C. Environment:

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

1. Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
 2. Controllers used in conditioned space are mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.
- D. Serviceability: Provide diagnostic LEDs for power, communication, and processor. Wiring connections are made to modular terminal strips or to termination card connected by ribbon cable.
- E. Memory: Building controller maintains BIOS and programming information in event of power loss for at least 72 hours.
- F. Immunity to power and noise. Controller able to operate at 90 percent to 110 percent of nominal voltage rating and performs an orderly shutdown below 80 percent nominal voltage. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3-feet.
- G. Controller to have a battery to provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery backup to maintain real-time clock functions for a minimum of 10 days.

2.7 APPLICATION SPECIFIC CONTROLLERS

- A. Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers to be fully programmable using graphical programming blocks.
1. ASC controllers communicate with other devices on internetwork.
 2. Each ASC capable of stand-alone operation without being connected to network.
 3. Each ASC will contain sufficient I/O capacity to control target system.
 4. Application controllers to include universal inputs with minimum 10-bit resolution that accept thermistors, 0-10VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be either analog or digital with at least 1 input that accepts pulses. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller to include binary and analog outputs on board. Provide analog outputs switch selectable as either 0-10VDC or 0-20mA. Software to include scaling features for analog outputs. Application controller to include 24VDC voltage supply for use as power supply to external sensors.
 5. Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

controller 10 times per second and capable of multiple PI and PID loops for control of multiple devices. Calculations completed using floating-point math and system to support display of information in floating-point nomenclature at operator's terminal. Programming of application controller completely modifiable in the field over installed BAS LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen.

6. Application controller to include support for room sensor. Display on room sensor programmable at application controller and include an operating mode and a field service mode. Provide button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

B. Communication:

1. Controller resides on network using MS/TP Data Link/Physical layer protocol.
2. Each controller connected to building controller.
3. Each controller capable of connection to laptop computer or portable operator's tool.

C. Environment:

1. Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
2. Controllers used in conditioned space mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D. Serviceability: Provide diagnostic LEDs for power, communication, and processor.

E. Memory: ASC use nonvolatile memory and maintains BIOS and programming information in event of power loss.

2.8 INPUT/OUTPUT INTERFACE

- A. Input/output points protected such that shorting of point to itself, to another point, or to ground will cause no damage to controller. Input and output points protected from voltage up to 24 V.
- B. Binary inputs (BI or DI) allow monitoring of On/Off signals from remote devices. Binary inputs sense "dry contact" closure without external power (other than that provided by controller) being applied.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- C. Pulse accumulation input objects accept up to 10 pulses per second for pulse accumulation.
- D. Analog inputs (AI) allow monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD).
- E. Binary outputs (BO or DO) provide for On/Off operation or pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers have three-position (On/Off/Auto) override switches and status lights. Outputs selectable for either normally open or normally closed operation.
- F. Analog outputs (AO) provide a modulating signal for control of end devices. Outputs provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building controllers have status lights and two-position (AUTO/MANUAL) switch and adjustable potentiometer for manual override. Analog outputs not exhibit drift of greater than 0.4 percent of range per year.
- G. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms run zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.9 POWER SUPPLIES AND LINE FILTERING

- A. Control transformers UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits. Limit connected loads to 80 percent of rated capacity.
- B. DC power supply output match output current and voltage requirements. Unit operates between 32 degrees F and 120 degrees F.
- C. Line voltage units UL listed and CSA approved.
- D. Power line filtering. Provide transient voltage and surge suppression for workstations and controllers.

2.10 CONTROL PANELS

- A. Control Panels:
 - 1. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures to be NEMA 12 when installed in other than a clean environment. Outdoor enclosures must be NEMA 3R. Provide (hinged door) key-lock latch and removable subpanels. Single key common to field panels and subpanels. In existing campus or building settings, key lock to match existing

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

keys.

2. Interconnections between internal and face-mounted devices prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.
4. Provide laminated plastic nameplates for enclosures in any mechanical room or electrical room labeled with TCP number. Laminated plastic to be 1/8-inch thick sized appropriately to make label easy to read.

2.11 AUXILIARY CONTROL DEVICES

A. Temperature Instruments:

1. Low-voltage or Line-voltage Thermostats: Bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating, exposed setpoint adjustment on cover with heat anticipator. Thermostat operates within 55 degrees F to 85 degrees F setpoint range, with 2 degrees F maximum differential.
2. Room Temperature Sensors: Thermistor or platinum RTD type with accuracy of plus or minus 0.5 degrees F at 70 degrees F; operating range 30-120 degrees F; linear signal; single point sensing element in wall-mounted ventilated enclosure with insulating back plate if mounted on exterior wall; plug-in portable operators terminal port.
3. Room Temperature Sensor: Thermistor or platinum RTD type with accuracy of plus or minus 0.5 degrees F at 70 degrees F; operating range 30-120 degrees F; linear signal; single point sensing element in wall-mounted ventilated enclosure with insulating back plate if mounted on exterior wall; push button for occupancy override; digital setpoint adjustment plus or minus 2 degrees F in both directions; LCD temperature display indicating setpoint only. Setpoint adjustment to revert to building programmed standard temperature upon next building occupancy schedule change (user adjustable). Room temperature sensor may have integral space carbon dioxide sensor with minimum performance characteristics identified within this specification. Include integral occupancy sensor for public rooms but not in offices.
4. Averaging Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F, consisting of array of single point sensing elements, securely mounted in duct or plenum; operating

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

range 20-120 degrees F; linear signal; 1-foot element per 2 SF of duct cross-sectional area. Use when duct is 9 SF or larger or where air is subject to temperature stratification.

5. Probe Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F, consisting of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 24-inch rigid probe. Use where duct is less than 9 SF cross-sectional area.
6. Outside Air Temperature Sensor: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F; Range -58 to 120 degrees F, single element, linear, with weather and sun shield for exterior mounting.
7. Low Temperature Limit Thermostat: Minimum 20 foot capillary sensing element, triggering on low temperature as sensed by any 12-inch segment; snap acting, normally open contacts, manual reset, line voltage.
8. Liquid Immersion Temperature Sensor: Thermistor or platinum RTD element, with accuracy of plus or minus 0.5 degrees F at 32 degrees F, stainless steel well and assembly, range 30 to 250 degrees F.
9. Pneumatic Room Thermostat: Two-pipe relay type with concealed adjustment, and no thermometer, blank cover secured with Allen screws.

B. Motorized Control Dampers:

1. Performance: Maximum leakage of 3 CFM/SF at 1-inch WG differential pressure, AMCA Class 1A, maximum pressure rating of 13-inch WG differential pressure, maximum velocity of 6,000 fpm, -72 degrees F to 275 degrees F temperature rating.
2. Multi-blade type, except where either dimension is less than 10-inch single blade may be used. Maximum blade length to be 48-inch.
3. Provide parallel blades for modulating mixing service and opposed blades for throttling service.
4. Blades to be interlocking; minimum 16 gauge galvanized steel; compression type edge seals and side seating stops. In copper, aluminum and stainless steel duct work, damper material matches duct work material.
5. Damper blades are reinforced, have continuous full length axle shafts, axle to axle linkage, and/or operating "jackshafts" as required to provide coordinated tracking of blades.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

6. Bearings: Self-lubricating stainless steel sleeve or Celcon bearing.
 7. Dampers over 25 SF in area to be in two or more sections, with interconnected blades.
 8. Provide remote damper blade position status with binary input.
 9. Tested in accordance with AMCA Standard No. 500.
- C. Motorized Control Valves:
1. Body pressure rating and connection type construction conforms to pipe, fitting and valve schedules.
 2. Fluid valve close-off ratings and spring ranges operate at maximum flows and maximum available pump heads scheduled without leakage.
 3. Screwed ends except 2-1/2-inch and larger valves with flanged ends.
 4. Steam valve close-off ratings operates at 150 percent of steam pressure without leakage.
 5. Pressure drop equal to twice pressure drop through heat exchanger (load), 50 percent of pressure difference between supply and return mains, or 5 PSI, whichever is greater, except two-position valves to be line size.
 6. Steam Valves: Body and trim materials in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service. Sizing Criteria:
 - a. Two-Position Service: Pressure drop 10 percent to 20 percent of inlet PSIG.
 - b. Modulating Service: 15 PSIG or less; pressure drop 80 percent of inlet PSIG.
 - c. Modulating Service: 16 to 50 PSIG; pressure drop 50 percent of inlet PSIG.
 - d. Modulating Service: Over 50 PSIG; pressure drop as scheduled on Drawings.
- D. Electric Damper/Valve Actuators:
1. Provide mechanical or electronic stall protection for each actuator.
 2. Where indicated provide internal mechanical, spring-return mechanism or provide uninterruptible power supply (UPS). Non-spring-return actuators have

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

external manual gear release to position damper/valve when actuator is not powered.

3. Proportional actuators accepts 0 to 10 VDC or 0 to 20 mA control signal and provide 2 to 10 VDC or 4 to 20 mA operating range.
4. Actuator sized for torque required plus 25 percent; UL or CSA listed; electronic current overload protection.
5. For system differential pressure control valves, provide fast acting valve actuator with valve open or close time of 30 to 60 seconds.
6. VAV Actuators: Actuators proportional 24 VAC actuators using a 4 to 20 mA range of control signals; stops automatically at end of travel; include permanently lubricated gear train.

E. Relays:

1. Control relays UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage to be suitable for application.
2. Time delay relays UL listed solid-state plug-in type with adjustable time delay. Delay adjustable plus or minus 200 percent (minimum) from setpoint or as indicated. Contact rating, configuration, and coil voltage to be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

F. Override Timers: Override timers spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer suitable for flush mounting on control panel face and located on local control panels or where shown.

G. Current Transmitters:

1. AC current transmitters are self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit range compatible with actual applied span of current value, with internal zero and span adjustment and plus or minus 1 percent full-scale accuracy at 500 ohm maximum burden.
2. Transmitter meets or exceeds ANSI/ISA S50.1 requirements and UL/CSA recognized.
3. Unit split-core type for clamp-on installation on existing wiring.

H. Current Transformers: AC current transformers UL/CSA recognized and completely encased (except for terminals) in approved plastic material; plus or minus 1 percent

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

accuracy at 5 A full-scale.

- I. Voltage Transmitters: AC voltage; self-powered single-loop (two-wire) type; 4 to 20 mA output with zero and span adjustment; UL/CSA recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1. Ranges include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with plus or minus 1 percent full-scale accuracy with 500 ohm maximum burden.
- J. Voltage Transformers: AC voltage transformers UL/CSA recognized, 600 VAC rated; built-in fuse protection; suitable for ambient temperatures of 40 degrees F to 130 degrees F; plus or minus 0.5 percent accuracy at 24 VAC and a 5 VA load.
- K. Overflow Switch: Insertion flow sensor, brass, impeller flow design with analog transmitter unit. Data Industrial Model 220BR.
- L. End Switches: Turret head Type SPDT. Schneider Electric/Square D Class 9007, Type C54B2, or approved equivalent.
- M. Water Detector: Cast aluminum enclosure with adjustable legs; gold plated probes for water detection; LED for water detection; SPDT alarm contacts; 24 VAC/VDC. Kele WD-1B, or approved equivalent.
- N. Tape Style Water Detector: Adhesive sensor tape with copper fiber electrodes and netted cover; tape integrity self-check feature; 24 VAC/VDC. Manufacturer: Kele WD-2-T.
- O. Spot Leak Water Detector: Polymer coated sensing probes; adjustable height; 24 VAC/VDC. Manufacturer: Kele SD-R01, or approved equivalent.

2.12 WIRING AND RACEWAYS

- A. General: Provide copper wiring, plenum cable, and raceways as specified in applicable Sections of Division 26, Electrical.
- B. Insulated wire to be copper conductors, UL labeled for 90 degrees C minimum service.
- C. Field panels and controllers to be supplied by building emergency power system where systems being monitored or controlled are on emergency power.
- D. Run control wiring as follows:
 - 1. Mechanical Rooms: In conduit.
 - 2. Exposed in Building Spaces: In conduit.
 - 3. Concealed in Building Walls and Ceilings: Plenum rated cable.
 - 4. Concealed in Building Ceilings: Plenum rated cable in cable tray.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- E. Field and Subfield Panels: Voltage in panels not-to-exceed 120 volts.
- F. Motor Control Centers: Responsibility for correct voltage of holding coils and starter wiring in pre-wired motor control centers interfacing with automatic controls is included hereunder.
- G. Wiring for BAS systems communications buses two conductor minimum 18 gauge foil-shielded, stranded twisted pair cable rated at 300 VDC or more than 80 degrees C.

2.13 SMOKE DETECTION (FOR PROJECTS WITH A FIRE ALARM SYSTEM)

- A. See Division 28 for Products.

PART 3 - EXECUTION

3.1 DEMOLITION

- A. Terminal Devices: Remove terminal sensors, actuators and controls as indicated on drawings and as required to accommodate scope of mechanical work shown on drawings and described in specifications. Remove pneumatic piping and cap with hardware as appropriate. Remove wiring and conduit associated with devices. Do not leave any unused abandoned piping or wiring in space. Remove pneumatic piping, wiring and conduits, including all appurtenances back to the main.
- B. Graphics and Programming: Remove symbols from control system graphics associated with deleted terminal elements. Modify programming code to delete alarms, control loops, etc., associated with deleted terminal devices.

3.2 EXAMINATION

- A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.
- B. Notify the Owner's Authorized Representative in writing of conditions detrimental to the proper and timely completion of the work.
- C. Do not begin work until unsatisfactory conditions are resolved.

3.3 CONTROL SYSTEM CHECKOUT AND TESTING

- A. Testing completed before Owner's Authorized Representative is notified of system demonstration.
- B. Calibrate and prepare for service of instruments, controls, and accessory equipment furnished under this specification.
- C. Verify that control wiring is properly connected and free of shorts and ground faults.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- D. Enable control systems and verify calibration and operation of input and output devices.
- E. Verify that system operation adheres to sequences of operation.
- F. Commissioning and Verification: In addition to commissioning requirements specified elsewhere, provide the following commissioning on the HVAC instrumentation and controls system:
 - 1. Control systems completely commissioned to ensure aspects of the system are operating as intended and at optimum tuning.
 - 2. Wiring connections verified and traced from field device to panel to ensure proper connections.
 - 3. Measured values verified by a hand held calibrated device to validate that value indicated by the control system is in fact the actual measured value.
 - 4. Loops properly tuned to obtain the desired control value. Each loop to be "upset" and put back in control to demonstrate its ability to stabilize quickly.
 - 5. Provide a final point-by-point report submitted that indicates the date of each verification, the results, and initialed on each page by the person performing the reading.

3.4 ACCEPTANCE TESTING AND TRAINING

- A. Site Testing:
 - 1. Contractor provides personnel, equipment, instrumentation, and supplies necessary to perform testing. Owner or Owner's Authorized Representative will witness and sign off on acceptance testing.
 - 2. Contractor demonstrates compliance of completed control system with Contract Documents. Using approved test plan, physical and functional requirements of project demonstrated.
- B. Training:
 - 1. General: Contractor conducts training courses for up to three other designated personnel in operation and maintenance of system. Training manuals provided for each trainee, with two additional copies provided for archival at project site. Manuals include detailed description of subject matter for each lesson. Copies of audiovisuals delivered to Owner. Training day is defined as 4 hours of classroom instruction, including two 15-minute breaks and excluding lunch time, Monday through Friday, during normal first shift in effect at training facility. Notification of any planned training given to Owner's Authorized Representative at least 15 days prior to training.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

2. Operator's Training I: Course taught at project site for a period of one training day after completion of contractor's field testing. Course includes instruction on specific hardware configuration of installed system and specific instructions for operating installed system. Upon completion, each student should be able to start system, operate the system, recover system after failure, and describe specific hardware architecture and operation of system.
3. Operator's Training II: Course taught at project site for period of one training day no later than six months after completion of the acceptance test. Course will be structured to address specific topics that students need to discuss and to answer questions concerning operation of system. Upon completion, students should be fully proficient in system operation and have no unanswered questions regarding operation of installed system.

3.5 COMMUNICATION WIRING

- A. Follow manufacturer's installation recommendations for communication cabling.
- B. Verify integrity of network following cable installation.
- C. Communication wiring unspliced length when that length is commercially available; labeled to indicate origination and destination data.
- D. Grounding of coaxial cable in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.6 WIRING AND RACEWAYS

- A. Provide electrical wiring required to control systems specified in this Section. Control and interlock wiring complies with national, state and local electrical codes and Division 26, Electrical of this specification.
- B. Power wiring required for building control panel(s) to be dedicated circuit(s).
- C. Verify location of operator work station with Owner prior to installation.
- D. NEC Class 1 (line voltage) wiring UL Listed in approved raceway according to NEC and Division 26, Electrical requirements.
- E. Low-voltage wiring meets NEC Class 2 requirements. (Low-voltage power circuits subfused when required to meet Class 2 current limit.)
- F. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for intended application.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- G. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for purpose of interfacing (e.g., relays and transformers).
- H. Where Class 2 wiring is run exposed, wiring run parallel along surface or perpendicular to it and tied at 10 foot intervals.
- I. Where plenum cables are used without raceway, support from structural members. Do not support cables with ductwork, electrical raceways, piping, or ceiling suspension systems.
- J. Make wire-to-device connections at terminal block or terminal strip. Make wire-to-wire connections at terminal block.
- K. Maximum allowable voltage for control wiring 24 V. If only higher voltages are available, provide step-down transformers.
- L. Wiring installed as continuous lengths, with no splices permitted between termination points.
- M. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at penetrations.
- N. Include one pull string in each raceway 1-inch or larger.
- O. Control and status relays are to be located in designated enclosures. Enclosures include packaged equipment control panels unless they also contain Class 1 starters.
- P. Install raceway to maintain a minimum clearance of 6-inches from high-temperature equipment (e.g., steam pipes or flues).
- Q. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
- R. Install insulated bushings on raceway ends and openings to enclosures. Seal top end of vertical raceways.
- S. Flexible metal raceways and liquid-tight, flexible metal raceways not-to-exceed 3-feet in length and be supported at each end. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways to be used.
- T. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections joined with couplings. Terminations made with fittings at boxes.
- U. Input and output terminations to be labeled at the controller to identify if they are AI, DI, AO, DO, and function (i.e. pump start, OM Sensor).

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

3.7 INSTALLATION OF AUXILIARY CONTROL DEVICES

A. General:

1. Install sensors and thermostats in accordance with manufacturer's recommendations.
2. Room sensors and thermostats installed at 48-inches AFF to top of sensor on concealed junction boxes properly supported by wall framing at the locations shown on the Drawings.
3. Low-limit sensors used in mixing plenums installed in a serpentine manner horizontally across duct.
4. Pipe-mounted temperature sensors installed in wells with heat-conducting fluid in thermal wells.
5. Install outdoor air temperature sensors on north facing wall or screen, complete with sun shield at designated location.
6. Chiller or Heat Pump differential pressure sensor: Locate immediately at the chiller or heat pump piping connections, before any fittings or accessories.

B. Flow Switch: Use correct paddle for pipe diameter. Adjust flow switch in accordance with manufacturer's instructions.

C. Actuators:

1. General:

- a. Mount and link control damper actuators according to manufacturer's instructions.
- b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

2. Actuator Mounting for Damper and Valve Arrangements to Comply with the Following:

- a. Damper Actuators: Do not install in the air stream.
- b. Use a weather proof enclosure (clear and see through) if actuators are located outside.
- c. Damper or valve actuator ambient temperature not-to-exceed 122 degrees F through any combination of medium temperature or surrounding air. Provide appropriate air gaps, thermal isolation washers

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

or spacers, standoff legs, or insulation as necessary. Mount per manufacturer's recommendations.

- d. Actuator cords or conduit to incorporate a drip leg if condensation is possible. Do not allow water to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point to be avoided to prevent water from condensing in conduit and running into actuator.
- e. Damper mounting arrangements to comply with the following:
 - (1) Furnish and install damper channel supports and sheet metal collars.
 - (2) Jack shafting of damper sections not allowed.
 - (3) Multi-section dampers arranged so that each damper section operates individually. Provide one electronic actuator direct shaft mounted per section.
- f. Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure and damper type. In general: Damper section not-to-exceed 24 ft-sq. with face velocity 1500 FPM.
- g. Multiple section dampers of two or more arranged to allow actuators to be direct shaft mounted on the outside of the duct.
- h. Multiple section dampers of three or more sections wide arranged with a 3-sided vertical channel (8-inch wide by 6-inch deep) within the duct or fan housing and between adjacent damper sections. Vertical channel anchored at the top and bottom to the fan housing or building structure for support. Connect sides of each damper frame to the channels. Holes in the channel to allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Face open side of channel downstream of the airflow, except for exhaust air dampers.
- i. Multiple section dampers to be mounted flush within a wall or housing opening to receive either vertical channel supports as described above or sheet metal standout collars. Sheet metal collars (12-inch minimum) to bring each damper section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.

D. Control Valve:

- 1. Valves installed in accordance with manufacturer's recommendations.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

2. Slip-stem control valves installed so that stem position is not more than 60 degrees from vertical up position. Ball type control valves installed with stem in horizontal position.
 3. Control valves accessible and serviceable.
 4. Install isolation valves so that control valve may be serviced without draining supply/return side piping system. Install unions at connections to screw-type control valves.
- E. Control Damper:
1. Dampers installed in accordance with manufacturer's instructions. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
 2. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.8 WATER DETECTOR

- A. Mount by applying a silicone adhesive to the mounting feet. For more permanent installations, fasten the sensor using the 0.19-inch holes provided in the mounting feet with #6 or #8 screws.

3.9 SMOKE DETECTION (FOR PROJECTS WITH A FIRE ALARM SYSTEM)

- A. Smoke detector furnished and powered/wired under Division 28, Electronic Safety and Security. Coordinate with fire alarm equipment supplier. Installation of duct smoke detector housing and sampling tube under Division 23, HVAC.
- B. Install smoke detectors in return air systems greater than 2000 CFM.
- C. Install smoke detectors at each story prior to connection to return air riser in systems greater than 15,000 CFM and serving more than one story.

3.10 SEQUENCES OF OPERATION AND POINTS LISTS

- A. Where local energy code dictates certain sequences (such as night setback, night flush, pressure and temperature reset, terminal unit sequences, etc.), the sequences are not necessarily repeated in the documents. It is not the intent of this specification or documentation to reiterate the energy code. Provide energy code mandated sequences and document in sequence of operations submittals at no additional cost to the Owner. Provide required points to achieve the appropriate sequences.
- B. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials to be centered on the associated setpoint. Modulating feedback control loops

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

to include the capability of having proportional, integral, and derivative action. Unless the loop is specified “proportional only” or “P+I”, Contractor to apply appropriate elements of integral and derivative gain to each control loop to result in stable operation, minimum settling time and maintain the primary variable within the specified maximum allowable variance.

- C. Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:
1. Occupied Period: Period of time when the building is in use and occupied. Confirm schedule with Owner. Exclude all national holidays. Generally systems will be fully operational throughout this period and ventilation air to be continuously introduced. Space temperature setpoints will generally be in the “normal” range of 68 degrees to 78 degrees F.
 2. Unoccupied period: Period of time when the building or zone is not in use and unoccupied. Ventilation air not to be introduced.
 3. Preoccupancy Period: Time prior to the Occupied period when the systems are returning the space temperatures from setback to “normal” or occupied setpoints (warm-up and cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling or to support a pre-occupancy purge sequence. Time period to be determined by an optimum start strategy unless otherwise specified.
 4. Setback Period: Setback will typically start with the end of the occupied period and end with the start of the preoccupancy period, however it shall be provided with its own schedule. Generally systems will be off except to maintain a “setback” temperature, economization may be enabled to maintain “setback” cooling setpoint when applicable.
- D. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level. For these points, it is unacceptable to have to modify programming statements to change the setpoint.
- E. When a power failure is detected in any phase, the BAS start commands to be retracted immediately from electrically powered units served by the failed power source. If the associated controller is powered by normal or emergency power, it may monitor its own power source as an indication of power status. If the controller is powered by uninterruptible power supply (UPS), or if it is not capable of monitoring its own power for use in sequences, provide at least one voltage monitor (three phase when applicable) per building. When the BAS detects that normal or emergency power has been restored, all equipment for which the BAS start command had been retracted to be automatically restarted in an orderly manner on staggered 5 second intervals to minimize inrush current.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- F. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, employ one of the following methods:
1. Determine a fixed reset schedule to result in stable operation and maintain the primary variable within the specified maximum allowable variance.
 2. Use a floating reset algorithm which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment to be chosen to maintain the primary variable within the specified maximum allowable variance.
 3. Primary variable to control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices to still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term to be selected to maintain the primary variable within the specified maximum allowable tolerance while minimizing overshoot and settling time. Gain prior approval for implementing this method of reset.
- G. Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, employ the following method:
1. Use a floating reset algorithm which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g., space temperature) setpoint. The reset increment to be determined by the quantity of “need heat” or “need cool” requests from individual SCU's. A SCU's “need heat” virtual point to activate whenever the zone's space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A SCU's “need cool” virtual point to activate whenever the zone's space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment to be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values to limit the setpoint range.
- H. Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method to be employed:
1. A floating reset algorithm to be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g., cooling valve, heating valve, damper position) setpoint of 85 percent open. The reset increment to be calculated based on the

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence to be chosen to maintain the primal variable within the specified maximum allowable variance while overshoot and settling time. The BAS analog output value to be acceptable as indicating the position of the control device.
2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the “need heat” or “need cool” virtual point to increment by one unit each time a zone's valve/damper position rises to greater than 95 percent. The quantity of “need heat” or “need cool” points to then be the basis for reset.
- I. Where “prove operation” of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS, after an adjustable time delay after the device is commanded to operate (feedback delay), confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm to be enunciated audibly. Upon failure, run command to be removed and the device to be locked out until the alarm is manually acknowledged unless specified otherwise.
 - J. BAS to provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:
 1. Speed control of variable speed drives
 2. Control Reset Loop
 3. Valve Travel Limit
 - K. Wherever a value is indicated to be dependent on another value (i.e., setpoint plus 5 degrees F) BAS to use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points to be provided. One to store the parameter (5 degrees F), one to store the setpoint, and one to store the value which is the result of the equation.
 - L. Trend points as identified in the points list. Trends to be grouped system specific and setup in two-axis (x,y) graphical format that display object values relative to time. Setup trends to record data in 5 minute increments.
 - M. Energy Recovery Ventilator
 1. General: ERV unit controller receives a signal from the building controller to initiate occupied or unoccupied mode. ERV to be in occupied mode during normal schedule building hours. During after-hours schedule the ERV to be in unoccupied mode.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

2. ERV unit provided with factory mounted microprocessor-based controller to receive input from building controller.
3. Factory mounted controls to modulate electric preheater as necessary for frost protection.
4. Occupied Mode:
 - a. Outdoor air damper modulates open.
 - (1) Provide 60 second ERV start delay after outdoor air damper modulates open.
 - b. ERV to run at a constant volume, as scheduled, continuously while in occupied mode.
 - c. Unit to normally operate in energy recovery mode.
 - d. Unit to enter bypass mode when the outdoor entering air temperature is within 5 deg F (adj) of the return air temperature.
5. Unoccupied Mode:
 - a. ERV to be shut down, if operating, and disabled from operating.
 - b. Outdoor air damper modulates closed.
 - c. Provide 60 second delay to closing outdoor air damper after ERV shut down.
6. Alarms:
 - a. Dirty Filter: Generate an alarm based on time duration, 6 months (adj).
 - b. General ERV Alarm: Generate an alarm if alarm contact on ERV is active.
7. Energy Recovery Ventilator Points List:

POINTS LIST	ANALOG IN	ANALOG OUT	DIGITAL IN	DIGITAL OUT	ALARMS	TREND
ERV Enable/Disable			X			X
Supply Fan Speed	X					
Exhaust Fan Speed	X					
OA Entering		X				X

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

Air Temp.						
OA Leaving Air Temp.		X				X
EA Entering Air Temp.		X				X
ERV Mode			X			X
Bypass Mode			X			
OA Damper Command	X					X
Dirty Filter			X		X	

N. Electric Duct Heater:

1. General: Electric coil controller receives signal from building controller, which initiates occupied or unoccupied mode.
 - a. Temperature sensor downstream of heating coil signals internal equipment controller to modulate electric coil to maintain setpoint (from BAS).
2. Occupied Mode: Electric duct heater to modulate as necessary to maintain a 70 deg F (adj) discharge air temperature.
 - a. Interlock EDH to only operate when associated ERV is operating.
 - b. Provide with airflow proving and temperature sensor accessories from the manufacturer.
 - c. When air temperature entering EDH is greater than 70 deg F unit to operate per unoccupied mode.
3. Unoccupied Mode:
 - a. Electric coil is off and disabled from operating.
4. Electric Duct Heater Points List:

POINT LIST	ANALOG IN	ANALOG OUT	DIGITAL IN	DIGITAL OUT	ALARMS	TREND
Enable/Disable Heat Pump			X			X
Discharge Air Temp. Setpoint	X					X
Discharge		X				X

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

Air Temp.							
-----------	--	--	--	--	--	--	--

- O. Split System Heat Pumps:
1. General: Split system heat pump unit controller receives a signal from the building controller to initiate occupied or unoccupied mode. Split system heat pumps to be in occupied mode during normal schedule building hours. During after-hours schedule the split system heat pumps to be in unoccupied mode.
 2. Occupied Mode:
 - a. Outdoor air damper modulates open.
 - b. Indoor FCU supply fan to run at constant, as scheduled, continuously while in occupied mode.
 - c. A wall mounted thermostat to signal the heat pump equipment controller. The equipment controller to modulate the heat pump and auxiliary electric coil to maintain the space temperature setpoint (from BAS) from the wall mounted thermostat.
 - (1) Spaces with radiant steam heaters:
 - (a) Radiant heaters to operate in parallel with the heat pump fan coil to maintain the heating setpoint. Upon space temperature dropping below space temperature setpoint the BAS to modulate the control valve as necessary to maintain the space temperature setpoint.
 - (b) Interlock controls for split system and radiator control valve to prevent simultaneous heating and cooling.
 3. Unoccupied Mode:
 - a. Outdoor air damper modulates closed.
 - b. Split system is shut down, if running, and disabled from operating.
 4. Alarms:
 - a. Dirty Filter: Generate an alarm based on time duration, 6 months (adj).
 - b. General System Alarm: Generate an alarm if alarm contact on the heat pump system is active.
 - c. Condensate Pump: generate an alarm upon condensate pump failing. Shut down heat pump fan coil.

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

- d. Leak Detection: generate an alarm upon the leak detection in the secondary drain pan being activated. Shut down heat pump fan coil.

5. Split System Heat Pump Control Points:

POINT LIST	ANALOG IN	ANALOG OUT	DIGITAL IN	DIGITAL OUT	ALARMS	TREND
Heat Pump System Enable/Disable			X			X
Space Temp. Setpoint	X					X
Space Temp.		X				X
OA Damper Command	X					
Discharge Air Temp.		X				
Steam Valve Command	X					X
Steam Valve Position		X				X
Condensate Pump				X	X	X
Heat Pump Alarm				X	X	X
Leak Detection				X	X	X

END OF SECTION

HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Equipment Drains and Overflows
 - 2. Unions
 - 3. Refrigerant Piping

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Welding Certificates: Copies of certificates for welding procedures and personnel.
 - 2. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Failed test results and corrective action taken to achieve requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Installer Qualifications: Company specializing in performing work of the type specified in this Section, with documented experience.

HVAC PIPING

2. Welder Qualifications: Certify in accordance with ASME (BPV IX).
3. ASME Compliance: Comply with ASME B31.9 "Building Services Piping" for materials, products, and installation. Provide safety valves and pressure vessels with the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 01.
4. Refrigerant Piping:
 - a. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX "Welding and Brazing Qualifications."
 - b. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
 - c. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."
 - d. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical" or UL 429 "Electrically Operated Valves."

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT DRAINS AND OVERFLOWS

- A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn.
 1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.
 2. Joints: Solder, lead free, ASTM B 32, HB alloy (95-5 tin-antimony), or tin and silver.

2.2 UNIONS

- A. Unions for Pipe 2-inches and Under:
 1. Ferrous Piping: 150 PSIG malleable iron, threaded, ASME B16.39.
 2. Copper Pipe: Bronze, soldered joints, ASME B16.22.
- B. Dielectric Connections: Provide dielectric waterway or brass nipple fitting with threaded ends. Dielectric unions are not allowed.

HVAC PIPING

2.3 REFRIGERANT PIPING

A. Piping:

1. Copper Tube: ASTM B 280, Type ACR, annealed-temper tube, clean, dry and capped.
 - a. Fittings: ASME B16.22 wrought copper.
 - b. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy (15 percent Silver).

B. Valves:

1. Manufacturers:
 - a. Hansen Technologies Corporation
 - b. Henry Technologies
 - c. Danfoss Flomatic
 - d. Substitutions: See Section 23 00 00, HVAC Basic Requirements, Division 00, Procurement and Contracting Requirements and Division 01, General Requirements.
2. Packaged Ball Valves:
 - a. Two piece bolted forged brass body with Teflon ball seals and copper tube extensions, brass seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of and maximum temperature of 300 degrees F.

C. Flexible Connectors:

1. Manufacturers:
 - a. Metraflex, VRF Flex, model VAV-RF8
 - b. Or approved equivalent.
2. Provide stainless steel refrigerant flexible connector with copper ends, operating at 700 psi, cleaned and bagged per PRAXAIR 99.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Install per manufacturer's written instructions and requirements.

HVAC PIPING

B. Preparation:

1. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
2. Remove scale and dirt on inside and outside before assembly.
3. Prepare piping connections to equipment with flanges or unions.
4. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

C. Above Grade Piping Installation:

1. Install per manufacturer's written instructions and requirements.
2. Install heating water, glycol, condenser water, piping to ASME B31.9 requirements. Install chilled water piping to ASME B31.5 requirements.
3. Route piping in orderly manner, parallel to building structure, and maintain gradient.
4. Install piping to conserve building space and to avoid interference with use of space.
5. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
6. Sleeve pipe passing through partitions, walls and floors allowing adequate space for pipe insulation.
7. Slope piping at 0.2 percent upward in direction of flow and arrange to drain at low points.
8. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
9. 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.
10. Drawings are diagrammatic and do not necessarily show top connections in all cases. Install branch connections to mains using tee fittings in main, with takeoff coming out of the top unless trade coordination conditions preclude it.
11. Anchor piping for proper direction of expansion and contraction.
12. Inserts:
 - a. Provide inserts for placement in concrete formwork.

HVAC PIPING

- b. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - c. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4-inches.
 - d. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - e. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.
13. Pipe Hangers and Supports:
- a. Install in accordance with Division 23, HVAC, Hangers and Supports.
 - b. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
 - c. Place hangers within 12-inches of each horizontal elbow.
 - d. Use hangers with 1-1/2-inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - e. Support vertical piping at top, bottom, and not less than every other floor. Support riser piping independently of connected horizontal piping.
 - f. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - g. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
 - h. Provide copper plated hangers and supports for copper piping.
 - i. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
14. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
15. Provide access where valves and fittings are not exposed.
16. Use eccentric reducers to maintain top of pipe level.

HVAC PIPING

17. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
18. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

D. Field Quality Control:

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 system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, provide closure 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.
6. Perform the following tests on hydronic piping:
 - a. 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.
 - b. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
 - c. Check expansion tanks to determine that they are not air bound and that system is full of water.
 - d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure not-to-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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

HVAC PIPING

- e. After hydrostatic test pressure has been applied for at least four hours, examine piping, joints and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 - f. Prepare written report of testing.
- E. Flushing and Cleaning of Piping Systems:
 - 1. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the piping systems in service. Provide temporary connections for cleaning, purging, and circulating fluids through the piping system.
 - 2. Use temporary strainers and temporary pumps that can create a minimum fluid velocity of 6-feet per second and maximum of 10-feet per second to flush and clean the piping systems. Do not use Owner's permanent strainers to trap debris during pipe flushing operations. Fit the temporary construction strainers with a line size blowoff valve.

3.2 REFRIGERANT PIPING INSTALLATION

- A. Install systems in accordance with ASHRAE Standard 15.
- B. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- C. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- D. Flood piping system with nitrogen when brazing.
- E. Follow ASHRAE Standard 15 procedures for charging and purging of systems and for disposal of refrigerant.
- F. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
- G. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- H. Fully charge completed system with refrigerant after testing.
- I. Install flexible connectors at connection to equipment with compressors or at fan coil units installed with a vibration isolator.
- J. Field Quality Control:
 - 1. Test refrigeration system in accordance with ASME B31.5.

HVAC PIPING

2. Pressure test system with dry nitrogen to 200 PSI. Perform final tests at 27-inches vacuum and 200 PSI using electronic leak detector. Test to no leakage.

END OF SECTION

HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Ductwork, Joints and Fittings
 - 2. Insulated Flexible Duct
 - 3. Drain Pans
 - 4. Ductwork Joint Sealers and Sealants

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.
- B. In addition, reference the following:
 - 1. Section 23 05 29, Hangers and Supports for HVAC Piping, Ductwork and Equipment.
 - 2. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Welding Certificates
 - 2. Field Quality Control Reports

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. NFPA Compliance:

HVAC DUCTS AND CASINGS

- a. NFPA 90A Installation of Air Conditioning and Ventilating Systems.
 - b. NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems.
2. Comply with NFPA 96, Ventilation Control and Fire Protection of Commercial Cooking Operations, Ch. 3, Duct System for range hood ducts, unless otherwise indicated.
 3. Comply with SMACNA's HVAC Duct Construction Standards - Metal and Flexible for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Provide sheet metal materials free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Duct design is generally diagrammatic and is not meant to be scaled. Major changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

PART 2 - PRODUCTS

2.1 DUCTWORK, JOINTS, AND FITTINGS

- A. Manufacturers:
 1. Ductmate
 2. Lindab Inc.
 3. Nexus Inc.
 4. SEMCO
 5. United McGill Corporation
 6. Ward Industries
- B. Materials:

HVAC DUCTS AND CASINGS

1. Galvanized Steel Ducts: Hot-dipped galvanized steel sheet, lock-forming quality, ASTM A 653/A 653M FS Type B, with G90/Z275 coating, minimum 26 gauge except where heavier material is specified. Ducts to have mill phosphatized finish for surfaces exposed to view.
- C. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 2. Deflection: Duct systems not-to-exceed deflection limits according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
 3. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
- D. Formed-On Flanges: construct according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible, Figure 1-4, using corner, bolt, cleat, and gasket details.
1. Duct Size: Maximum 30-inches wide and up to 2-inch wg pressure class.
 2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.
 3. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19-inches and larger and 0.0359-inch thick or less, with more than 10 SF of nonbraced panel area unless ducts are lined.
- E. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of material specified in this Section according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
1. Ducts up to 20-inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 2. Ducts 21- to 72-inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
 3. Ducts Larger than 72-inches in Diameter: Companion angle flanged joints per SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-2.
 4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system

HVAC DUCTS AND CASINGS

manufacturer's tolerances.

- F. 90-Degree Tees and laterals and Conical Tees: Fabricate to comply with SMACNA's HVAC Duct Construction Standards-Metal and Flexible, with metal thicknesses specified for longitudinal-seam straight ducts.
- G. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- H. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows to be 1.5 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's HVAC Duct Construction Standards-Metal and flexible, unless otherwise indicated.
 - 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa):
 - a. Ducts 3- to 36-inches in Diameter: 0.034-inch .
 - b. Ducts 37- to 50-inches in Diameter: 0.040-inch.
 - c. Ducts 52- to 60-inches in Diameter: 0.052-inch.
 - d. Ducts 62- to 84-inches in Diameter: 0.064-inch.
 - 3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
 - a. Ducts 3- to 26-inches in Diameter: 0.034-inch.
 - b. Ducts 27- to 50-inches in Diameter: 0.040-inch.
 - c. Ducts 52- to 60-inches in Diameter: 0.052-inch.
 - d. Ducts 62- to 84-inches in Diameter: 0.064-inch.
 - 4. 90-Degree, Two-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
 - 5. Round Elbows:
 - a. 8-inches and Less in Diameter: Fabricate die-formed elbows for 45 and 90-degree elbows and pleated elbows for 30, 45, 60 and 90 degrees only.

HVAC DUCTS AND CASINGS

Fabricate nonstandard bend-angle configurations or non-standard diameter elbows with gored construction.

- b. 9 through 14-inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60 and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 - c. Larger than 14-inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
- 6. Die-Formed Elbows for Sizes through 8-inches in Diameter and Pressures 0.040-inch thick with two-piece welded construction.
 - 7. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
 - 8. Pleated Elbows for Sizes through 14-inches in Diameter and Pressures through 10-inch wg (2500 Pa): 0.022-inch.
 - 9. Not acceptable:
 - a. Corrugated or flexible metal duct.
 - b. Adjustable elbows.

2.2 INSULATED FLEXIBLE DUCT

- A. Manufacturers:
 - 1. ATCO
 - 2. Flexmaster
 - 3. J.P. Lamborn Co.
 - 4. Hart and Cooley
- B. Construction: Standard factory fabricated product. Inner wall: Impervious vinyl or chlorinated polyethylene, permanently bonded to a vinyl or zinc-coated spring steel helix.
- C. Insulation: Fiberglass blanket insulation covered by an outer wall of vinyl or fiberglass-reinforced metalized vapor barrier.
- D. Listing: UL 181 listed Class 1 flexible air duct material. Overall thermal transmission: No more than 0.25 BTU/in or hr/sq. degrees F at 75 degrees F differential, per ASTM C335.
- E. Vapor transmission value no more than 0.10 perm, per ASTM E96.

HVAC DUCTS AND CASINGS

- F. Pressure Rating: 4-inch wg positive pressure and 1-inch wg negative pressure.
- G. Performance Air Friction Correction Factor: 1.3 maximum at 95 percent extension. Working air velocity: Minimum 2000 FPM.
- H. Flame Spread Rating: No more than 25.
- I. Smoke Development Rating: No more than 50 as tested per ASTM E84.
- J. Insertion Loss: Minimum attenuation of 29 DB for 10-foot straight length at 8-inch diameter at 500 Hz.

2.3 DRAIN PANS

- A. Primary Drain Pans: Stainless Steel, fabricated in accordance with ASTM A167 and A480.
- B. Secondary Drain Pans: Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A 653/A 653M FS Type B, with G90/Z275 coating.

2.4 DUCTWORK JOINT SEALERS AND SEALANTS

- A. Manufacturers:
 - 1. Ductmate
 - 2. Duro Dyne
 - 3. Hardcast
 - 4. United McGill Corporation
 - 5. Vulkem
 - 6. Foster
 - 7. Childer
- B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
- C. Low Emitting Materials Requirement: Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.
- D. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure and leakage class of ducts.
- E. Surface Burning Characteristics: Flame spread of zero, smoke developed of zero, when tested in accordance with ASTM E 84.

HVAC DUCTS AND CASINGS

- F. Water Based Sealant for Brush-On Application: Flexible, adhesive sealant, resistant to UV light, UL-181A, and UL-181-B listed, complying with NFPA requirements for Class 1 ducts. Min. 69 percent solids, nonflammable. Hardcast Versa-Grip 181; Childers CP-146; Foster 32-19 for SMACNA 1/2, 1, 2, 3, 4, 6, and 10-inch WG duct classes, and SMACNA Seal Class A, B, or C.
- G. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C920, Type S, Grade NS, Class 25, Use O.
- H. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.
- I. Polyurethane Sealant: General-purpose, exterior use, non-brittle sealant for gunned application. Vulkem 616 or equal.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. General: Use the following pressure seal, and leakage class(es) in design of ductwork specified in this section unless otherwise noted on Drawings.

SYSTEM	PRESSURE CLASS (Inches of Water)	SEAL CLASS	LEAKAGE CLASS ROUND DUCTS	LEAKAGE CLASS RECTANGULAR DUCTS
Low pressure (downstream of terminal unit)	+ 1-inch	A	3	6
Return and exhaust	0.5-inch more negative than return/exhaust fan pressure or -2-inch pressure class, whichever is more negative.	A	3	6

- B. Ductwork Installation:
 - 1. General: Install entire duct system in accordance with drawings, Specifications, and latest issues of local Mechanical Code, NFPA 90A, and SMACNA Duct Construction Manual. At Contractor's option, rectangular ductwork may be resized to maintain an equivalent air velocity and friction rate, while maintaining a maximum aspect ratio of 3. Remove markings and tagging from ductwork exterior surface in mechanical rooms and other locations where ductwork is exposed.

HVAC DUCTS AND CASINGS

2. The duct layout shown on the Contract Drawings is diagrammatic in nature. Coordinate the ductwork routing and layout, and make alterations to the ductwork routing and layout to eliminate physical interferences. Where deviations in the ductwork routing as shown in the Contract Drawings are required, alterations may be made so as not to compromise the air flow, pressure drop, and sound characteristics of the duct fitting or duct run as shown on the Contract Drawings. In the event Architect determines that the installed ductwork is inconsistent with the above mentioned criteria, remove and replace at no additional cost to the Owner.
3. Install ducts with fewest possible joints.
4. Install fabricated fittings for changes in directions, size, shape, and for connections.
5. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12-inches, with a minimum of 3 screws in each coupling.
6. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
7. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
8. Install ducts with a clearance of 1-inch, plus allowance for insulation thickness. Allow for easy removal of ceiling tile.
9. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
10. Coordinate layout with suspended ceiling, air duct accessories, lighting layouts, and similar finish work.
11. Electrical and IT Equipment Spaces: route ducts to avoid passing through transformer vaults, electrical equipment spaces, IDF/MPOE rooms, and enclosures.
12. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2-inches.
13. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Reference SMACNA's Seismic Restraint Manual: Guidelines for Mechanical Systems,

HVAC DUCTS AND CASINGS

Mason Seismic Restraint and Support Systems.

14. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's Duct Cleanliness for New Construction Advanced Level.
 15. Paint interiors of metal ducts, that do not have duct liner, for 24-inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible duct material.
 16. Install ductwork in the location and manner shown and detailed. Review deviations required by job conditions with Architect prior to any fabrication. Provide fittings for construction per SMACNA.
 17. Install flexible ductwork to limit sag between support hangers to 1/2-inch per foot of spacing support.
- C. Flanged Take-Offs:
1. Install at branch takeoffs to outlets using round or flex duct.
 2. Flanged take-offs secured with minimum 8-inch screw spacing (three screws minimum).
 3. Provide ductwork taps and branches off of main ducts at 45 degrees whether shown on Drawings or not (drawings are diagrammatic).
- D. Cleaning:
1. Clean duct systems with high power vacuum machines. Protect equipment that could be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.
 2. Grille and Exposed Duct Cleaning:
 - a. After completion of ductwork installation, operate each fan system (excluding exhaust fans) for a minimum of 30 minutes prior to installation of ceiling grilles and diffusers. After grilles and diffusers are installed, clean out accumulation of particles from grilles and diffusers prior to acceptance.
 - b. Clean exterior surface of ducts exposed to public view of chalk, pencil and pen marks, labels, sizing tags, dirt, dust, etc., so that upon completion of installation, ducts are left in clean and unblemished manufactured conditions.

HVAC DUCTS AND CASINGS

- c. Exposed duct and grilles to remain free of dust entrained streaks due to leakage at joints and grille connections during warranty period. Clean leaks, seal and refinish to match existing if visible streaks develop.

3.2 DUCTWORK, JOINTS AND FITTINGS INSTALLATION

A. Duct Materials - Applied Locations:

- 1. General: Use the following materials in design of ductwork specified in this Section unless otherwise noted on the Drawings.

Location or Application	Material
Supply, Return, Transfer, and Exhaust - Low Pressure (downstream of terminal units)	Single Wall, Galvanized Steel
Supply, Return, and Exhaust - Medium Pressure (upstream of terminal units)	Single Wall, Galvanized Steel

B. Ductwork Installation:

- 1. Fabricate radius elbows with centerline radius not less than 1-1/2 duct diameters.
- 2. Do not install duct size transition pitch angles which exceed 30 degrees for reductions in duct size in the direction of airflow, and 15 degrees for expansions in duct size in the direction of airflow.
- 3. Install fixed turning vanes in square throat rectangular elbows and in tees.
- 4. Fabricate duct turns with the inside (smallest) radius at least equal to the duct width (supply ducts) and 1.5 times radius (return and exhaust ducts). Where necessary, square elbows may be used, with maximum available inside radius and with fixed turning vanes. In healthcare settings such as hospitals and medical office buildings, square elbows and turning vanes allowed on supply ductwork only.

3.3 INSULATED FLEXIBLE DUCT INSTALLATION

A. Provide sheet metal plenum or rigid elbow and connect to diffusers and grilles with ductwork connections. Refer to Drawings for more information. Provide straight section of flexible duct with minimum length of 2-feet and maximum length of 5-feet and connect to sheet metal plenums and rigid elbows connected to diffusers and grilles, unless noted otherwise.

- 1. Provide round neck grilles/diffusers or square-to-round transitions. Flexible duct connections directly to diffuser and grilles is not allowed.
- 2. Flexible duct allowed in concealed spaces above lay-in ceilings only.

HVAC DUCTS AND CASINGS

3.4 DRAIN PANS INSTALLATION

- A. Install where shown on Drawings. Drain provided by Division 22, Plumbing. Provide drain (sized per code) connection from each drain pan and pipe to nearest floor drain through trap and 10-inch air gap. Drain pans over 6-feet in length require drain connections from both ends. Pitch drain pans in direction of air flow and to drain. Support secondary drain pan independently from equipment.

3.5 DUCTWORK JOINT SEALERS AND SEALANTS INSTALLATION

- A. Joints and Seam Joint Sealing:
1. Seal duct seams and joints according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible, for duct pressure class indicated.
 2. Seal transverse joints, longitudinal seams and duct wall penetrations including screw, fastener, pipe, rod, and wire.
 3. Seal ducts before external insulation is applied.
 4. Tape joints of PVC coated metal ductwork with PVC tape.
 5. Fasteners such as sheet-metal screws, machine screws or rivets to be cadmium plated.
 6. Rectangular Ductwork: Where intermediate joint reinforcement is required for duct of negative pressure class, pre-drill stiffening flange and provide fastener maximum 8-inches on center. Where retaining flanges are welded to duct wall, paint welds with zinc coating.
 7. Single Wall Round Ductwork: Joint to incorporate beaded slip collar with minimum #8 sheet metal screws 8-inches on center. Seal ductwork as specified in this Section.
 8. Seal joints and seams. Apply sealant to make end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
 9. Double Wall Round Ductwork: Joint to incorporate beaded slip collar or flanged connection, with minimum #8 sheet metal screws 8-inches on center. Seal ductwork as specified in this Section.
 10. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
 11. Provide openings in ductwork where required to accommodate thermometers and control devices. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against

HVAC DUCTS AND CASINGS

air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

12. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities as well as Code required clearances.

END OF SECTION

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Sheet Metal Materials
 - 2. Backdraft Dampers
 - 3. Dampers
 - 4. Concealed Damper Hardware
 - 5. Access Doors
 - 6. Duct Test Holes
 - 7. Turning Vanes
 - 8. Flexible Connectors

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Manufacturer's catalog data and fabrication/installation drawings for each factory fabricated duct accessory. Include leakage, pressure drop and maximum back pressure data.
 - 2. Shop Drawings: Indicate air duct accessories.
 - 3. Manufacturer's installation instructions: Provide instructions for each factory fabricated duct accessory.
 - 4. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

AIR DUCT ACCESSORIES

- a. See Division 01, General Requirements, Product Requirements for additional provisions.
- b. Extra Fusible Links: One of each type and size.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this Section, with minimum five years of documented experience.
 - 2. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
 - 3. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.
 - 4. AMCA 511 - Certified Ratings Program for Air Control Devices.
 - 5. AMCA 611, latest edition - Certified Ratings Program - Product Rating Manual for Airflow Measurement Stations.
 - 6. AMCA 610, latest edition - Laboratory Methods of Testing Airflow Measurement Stations for Performance Rating.
 - 7. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
 - 8. NFPA 92A - Smoke-Control Systems.
 - 9. NFPA 92B - Smoke Control Systems in Atria, Covered Malls and Large Areas.
 - 10. NFPA 101 - Life Safety Code.
 - 11. UL 555 - Standard for Safety; Fire Dampers.
 - 12. UL 555S - Standard for Safety; Leakage Rated Dampers for Use in Smoke Control Systems.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

AIR DUCT ACCESSORIES

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M. Galvanizing: 1-1/4 ounces per square foot total both sides; ducts to have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

2.2 BACKDRAFT DAMPERS

- A. Manufacturers:
 - 1. Air Balance
 - 2. Cesco
 - 3. Greenheck
 - 4. Nailor
 - 5. Ruskin
- B. Basis-of-Design: Ruskin CB D6.
- C. Description: Multiple-blade gravity balanced with center pivoted blades with sealed edges, assembled in rattle free manner with 90-degree stop, adjustment device to permit setting for varying differential static pressure.
- D. Frame: 0.125-inch thick 6063-T5 extruded aluminum channel with galvanized steel braces at mitered corners. Provide mounting flange.
- E. Blades: Single piece, overlap frame, parallel action, horizontal orientation, minimum 0.07-inch 6063-T5 extruded aluminum material, maximum 6-inch width.
- F. Bearings: Corrosion-resistant synthetic, formed as single piece with axles.
- G. Blade Seals: Extruded vinyl, mechanically attached to blade edge.

AIR DUCT ACCESSORIES

- H. Blade Axles: Corrosion-resistant, synthetic formed as single piece with bearings, locked to blade.
- I. Tie Bars and Brackets: Galvanized steel.
- J. Return Spring: Adjustable tension.
- K. Damper Capacity:
 - 1. Closed Position: Maximum back pressure of 16-inches water gauge.
 - 2. Open Position: Maximum air velocity of 2,500-feet per minute.
- L. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade. Must be capable of operating over wide range of pressures.
- M. Finish: Mill aluminum.
- N. Temperature Rating: -40 degrees F to 200 degrees F.
- O. Operation of Blade:
 - 1. Start to Open: 0.01-inch wg
 - 2. Fully Open: 0.05-inch.
- P. Pressure Drop: Maximum 0.15-inch wg at 1,500-feet per minute through 24-inch by 24-inch damper.
- Q. Factory Sleeve: Minimum 20 gauge thickness, 12-inches in length.
- R. Screen: At outdoor intake or discharge. 1/4-inch aluminum.

2.3 DAMPERS

- A. Manufacturers:
 - 1. Air Balance
 - 2. Cesco
 - 3. Greenheck
 - 4. Nailor
 - 5. Ruskin
- B. Basis-of-Design:

AIR DUCT ACCESSORIES

1. Rectangular ductwork for velocities and pressures up to 1,500 fpm and 2.5-inch wg, respectively: Ruskin MD-35.
 2. Rectangular ductwork for velocities and pressures up to 3,000 fpm and 4-inch wg, respectively: Ruskin CD-60.
 3. Round ductwork for velocities and pressures up to 3,000 fpm and 4-inch wg, respectively: Ruskin CDSR-15.
- C. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- D. Rectangular Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design with linkage concealed in frame and suitable for horizontal or vertical applications.
1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum 16 gauge thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - a. Roll-Formed Steel Blades: Galvanized sheet steel, 16 gauge thick for velocities up to 1,500 fpm, and 14 gauge thick for velocities up to 3,000 fpm.
 - b. Blade Axles: Minimum 1/2-inch diameter, plated steel, hex shaped, mechanically attached to blade.
 - c. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
 - d. Tie Bars and Brackets: Galvanized steel.
 - e. Mill galvanized.
- E. Round Volume Dampers: Single-blade suitable for horizontal or vertical applications.
1. Steel Frames: Galvanized, roll formed, minimum of 20 gauge thick with beads at each end.
 2. Blades: Minimum 14 gauge thick, galvanized sheet steel, round, single-piece.
 3. Blade Axles: Minimum 1/2-inch square, plated steel, mechanically attached to blade.

AIR DUCT ACCESSORIES

4. Bearings: Molded synthetic sleeve, turning in hole in frame.
 5. Finish: Mill galvanized.
 6. Capacity:
 - a. Closed Position: Maximum pressure of 4-inches wg.
 - b. Open Position: Maximum air velocity of 3,000-feet per minute.
 7. Leakage: Maximum 20 cfm at 4-inches wg.
 8. Pressure Drop: Maximum 0.02-inch wg at 1,500-feet per minute through 20-inch diameter dampers.
- F. Jackshaft: 1-inch diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
 2. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include 2-inch elevated platform for insulated duct mounting.

2.4 CONCEALED DAMPER HARDWARE

- A. Manufacturers:
1. Young Regulator Company
 2. Or approved equivalent.
- B. Concealed Damper Hardware: For dampers above non-removable ceilings (gyp, plaster, decorative, etc.) where access panels have not been shown on Architectural drawings or in locations where dampers are more than 2-feet above the ceiling, provide:
1. Concealed Damper Regulator: Young Regulator Company Model 315 or approved equivalent.
 2. Cable System: Young Regulator Company or approved equivalent.
 3. Controller: Young Regulator Company 270-275 or approved equivalent.
 4. Control wrenches, wire stops, casing nuts, and stainless steel wire.
 5. Paint cover plate to match ceiling color or as directed by Architect.

AIR DUCT ACCESSORIES

2.5 ACCESS DOORS

- A. Manufacturers:
 - 1. Ductmate
 - 2. Cesco
 - 3. Ruskin
 - 4. Nailor
 - 5. Outdoor Installation: Karp MX insulated exterior access door.
- B. Duct Pressure Class 2-inch WC and Greater: Sandwich-type design with threaded locking bolt assembly. Closed cell neoprene gasket permanently bonded to inside panel. Zinc-coated steel wing nuts or polypropylene molded knobs with threaded metal inserts - zinc coated bolts sealed to inner panel.
- C. Duct Pressure Class 1-1/2-inch WC and Less: Galvanized steel assembly incorporating frame, door, hinges, and latch(es). Frame tabbed for attachment to duct panel. Double wall door panel with 1-inch insulation. Open cell neoprene gasket attached to frame. Cam latches for tight closure.
- D. Plenum Doors: Extruded aluminum frames with extruded santoprene seals. Double-wall 20 gauge galvanized steel door panel with fiberglass insulation.
- E. Size: Maximum size available to fit rectangular duct panel dimension or round duct diameter. Plenum doors minimum 2-feet wide by 4-feet high.
- F. For outdoor installation, only provide waterproof access doors installed vertically.

2.6 DUCT TEST HOLES

- A. Manufacturers:
 - 1. Ventlok
 - 2. Or approved equivalent.
- B. Temporary Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- C. Permanent Test Holes (where shown on Drawings): Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

AIR DUCT ACCESSORIES

2.7 TURNING VANES

- A. Manufacturers:
 - 1. Aerodyne
 - 2. Ductmate Industries
 - 3. Duro Dyno Corp.
 - 4. Metalaire Inc.
- B. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners to automatically align vanes.
- C. Manufactured Turning Vanes: For medium pressure ductwork, ductwork upstream of terminal units, and in ductwork with equal inlet width and height dimensions and outlet width and height dimension, provide double thickness airfoil turning vanes. Low pressure ductwork and ductwork downstream of terminal units use either single thickness or double thickness turning vanes. For mitered rectangular elbows with changes in size from inlet to outlet, only use single thickness turning vanes. Use 2-inch radius vanes spaced on centers of 1.5-inches for single thickness. Use 2-inch radius vanes spaced on centers of 2.125-inches for double thickness.
- D. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.8 FLEXIBLE CONNECTORS

- A. Manufacturers:
 - 1. Duro Dyne Corp.
 - 2. Ventfabrics Inc.
 - 3. Ductmate Industries
 - 4. Hardcast
- B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 4-inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Select metal compatible with ducts.
- D. Provide a spring and bracket assembly to reinforce the fabric with sufficient tension to prevent connector collapse under negative or positive pressure. Number and positioning

AIR DUCT ACCESSORIES

of spring-link fixture to be determined by the manufacturer to maintain straight axis and without kinks between two sections of duct, or between duct and the moving element. Harcast Spring-Link SL-200, or equal.

- E. Indoor System, Flexible Connector Fabric (FC-I): Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 30 ounces per square yard.
 - 2. Tensile Strength: 395 pounds of force per inch in the warp and 255 pounds of force per inch in the filling.
 - 3. Service Temperature: -40 degrees F to 200 degrees F.

PART 3 - EXECUTION

3.1 DUCT ACCESSORIES GENERAL INSTALLATION

- A. Inspect areas to receive air duct accessories. Notify Engineer of conditions that would adversely affect the installation of the dampers. Do not proceed until conditions are corrected.
- B. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- C. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- D. Do not compress or stretch damper frames into duct or opening.
- E. Handle dampers using sleeve or frame. Do not lift dampers using blades, actuators, or jack shafts.
- F. Adjust duct accessories for proper settings.

3.2 SHEET METAL MATERIALS INSTALLATION

- A. Install bracing for multiple sections to support assembly weights and hold against system pressure. Install bracing as needed.

3.3 BACKDRAFT DAMPERS INSTALLATION

- A. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated. Provide at outside air intakes where motorized dampers are not shown on drawings.

AIR DUCT ACCESSORIES

3.4 DAMPERS INSTALLATION

- A. Where installing volume dampers in ducts with liner, avoid damage to and erosion of duct liner.
- B. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts for air balancing. Install at a minimum of two duct widths from each branch takeoff. Provide balancing dampers for all air inlets and outlets.
- C. Install dampers square and free from racking with blade running horizontally.

3.5 CONCEALED DAMPER HARDWARE INSTALLATION

- A. Coordinate location in Reflected Ceiling Plan and color of concealed damper hardware with Architect prior to installation.

3.6 ACCESS DOORS INSTALLATION

- A. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils.
 - 2. Downstream from volume dampers, turning vanes and equipment.
 - 3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
 - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot (15-m) spacing.
 - 5. Install the following sizes for duct-mounting, rectangular access doors:
 - a. One-Hand or Inspection Access: 8-inches by 5-inches.
 - b. Two-Hand Access: 12-inches by 6-inches.
 - c. Head and Hand Access: 18-inches by 10-inches.
 - d. Head and Shoulders Access: 21-inches by 14-inches.
 - e. Body Access: 25-inches by 14-inches.
 - f. Body Plus Ladder Access: 25-inches by 17-inches.
 - 6. Install the following sizes for duct-mounting, round access doors:
 - a. One-Hand or Inspection Access: 8-inches in diameter.
 - b. Two-Hand Access: 10-inches in diameter.

AIR DUCT ACCESSORIES

- c. Head and Hand Access: 12-inches in diameter.
- d. Head and Shoulders Access: 18-inches in diameter.
- e. Body Access: 24-inches in diameter.

7. Label access doors.

3.7 DUCT TEST HOLES INSTALLATION

- A. Provide test holes at fan inlets and outlets where indicated and where required for air testing and balancing.

3.8 TURNING VANES INSTALLATION

- A. Vanes must be installed, eliminating every other vane is not allowed.
- B. Single thickness vanes cannot be over 36-inches long without intermediate vane runner.
- C. Install per SMACNA and fasten/support to prevent vibration, noise, and to maintain proper alignment at design velocity.

3.9 FLEXIBLE CONNECTORS INSTALLATION

- A. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators. Provide sheet metal weather cover over flexible connections located outdoors. Attach sheet metal to either equipment side or ductwork side, but not both.
- B. Per NFPA, do not use flexible connectors on grease exhaust fans.
- C. Securely attach spring-lock brackets to the metal strips of the connector collar using No. 8 sheet metal screws.
- D. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- E. Adjust the following types in the following locations:
 - 1. FC-I: Indoors.

END OF SECTION

This page intentionally left blank

AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Grilles, Registers, Diffusers
 - 2. Gravity Intake and Relief Penthouses
 - 3. Roof Hoods

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
 - 2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
 - 3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size and accessories furnished.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Air Distribution Diffuser, Register, and Grille Schedule lists Basis of Design, with any specialty accessories, construction, finish or other criteria noted on schedule. Submitted air distribution must match criteria of Basis of Design:

AIR OUTLETS AND INLETS

- a. Construction materials and appearance.
- b. Frame/installation method.
- c. Isothermal throw plus or minus 5 percent at design flows shown on drawings.
- d. Noise Criteria: NC value plus or minus 1 at design flows shown on drawings.
- e. Accessories: Equal to Basis of Design.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 23, HVAC sections, where more than a single type is specified for the application, provide single selection for each product category.
- B. Grilles, Registers, Diffusers:
 1. Anemostat
 2. Carnes
 3. Environmental Air Products
 4. Krueger
 5. Metalaire
 6. Nailor
 7. Price Co.
 8. Shoemaker
 9. Titus
 10. Tuttle & Bailey
 11. Seiho
 12. Or approved equivalent.

AIR OUTLETS AND INLETS

C. Gravity Intake and Relief Penthouses:

1. Acme
2. Carnes
3. Greenheck
4. JencoFan
5. ILG
6. Cook
7. Penn
8. Or approved equivalent.

D. Roof Hoods:

1. Greenheck
2. Cook
3. Acme
4. Carnes
5. Penn

2.2 GRILLES, REGISTERS, DIFFUSERS

- A. Diffuser, Register and Grille Schedule lists Basis of Design, with specialty accessories, construction, finish or other criteria noted on schedule. Submitted air distribution must match criteria of Basis of Design, including accessories and finish:
1. Matching construction materials and appearance. Equal installation method/frame.
 2. Pressure drop equal to or less than Basis of Design at CFM on Drawings.
 3. Throw: Isothermal jet throw plus or minus 5 percent of Basis of Design at CFM listed on Drawings.
 4. Noise Criteria: Plus or minus 1 NC of Basis of Design at CFM listed on Drawings. If Basis of Design NC is below registered level, submitted must match. NC rating with 10 dB room factor or less.
- B. Provide 1-, 2-, 3-, or 4-way deflection as indicated on Drawings.

AIR OUTLETS AND INLETS

- C. Provide pattern controllers for linear supply air diffusers.
- D. Register Dampers: Dampers utilized with grilles. Opposed blade dampers utilizing a side operated worm drive which provides external duct operation. Slot the end of the shaft to receive a screwdriver. Factory assembled side operator. Construct of the same material as the grille. Manufacturer same as grilles/diffuser.
- E. Coordinate mounting frames with ceiling construction type. Verify per reflected ceiling plans.

2.3 GRAVITY INTAKE AND RELIEF PENTHOUSES

- A. Stormproof, gravity type. Penthouse: Aluminum or fiberglass. Cover: Removable and lined with fiberglass insulation to prevent condensation. Provide aluminum bird screen, roof curb, and anti-condensation coating.
- B. Finish: factory prime coat finish color to be selected.

2.4 ROOF HOODS

- A. Unit Description: Hooded high-efficiency roof-mounted gravity ventilator.
- B. Bolted and welded construction utilizing corrosion resistant fasteners. Construct hood of minimum 18 gauge aluminum, bolted to a minimum 8 gauge aluminum support structure. A radius throat must be provided for optimum performance. Provide lifting lugs to help prevent damage from improper lifting. Provide rain gutter to prevent rain infiltration. Continuously welded curb cap corners on base for maximum leak protection. Mount birdscreen constructed of 1/2-inch galvanized mesh in the hood. Unit to bear an engraved aluminum nameplate and shipped in ISTA Certified Transit Tested Packaging. Provide manufacturer's roof hood, minimum 14-inches high. Verify height with roofing and insulation depth prior to ordering.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Install in accordance with manufacturer's instructions. Provide seismic supports, clips, and bracing per local code. Coordinate installation of framing. Provide complete coverage of rough openings by integral device flanges or auxiliary frames. Where above ceiling location is unconditioned space, caulk rough openings; repair and re-paint locations where dust entrainment streaks develop due to unsealed openings.
- B. Damp locations, such as lockers, restrooms, showers, natatoriums, whirlpool/spas, to have aluminum construction even if scheduled otherwise; mounting hardware to be stainless steel.

AIR OUTLETS AND INLETS

- C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- D. Unless otherwise shown on drawings, for ceiling mounted air outlets with adjustable airflow pattern controllers mounted at a height of 12 feet or less, adjust the air outlets for horizontal air distribution, and adjust to vertical air distribution for ceiling height above 12 feet.
- E. Exterior color of grilles per Architect. White finish if not otherwise scheduled or noted by Architect. Paint ductwork visible behind air outlets and inlets matte black.
- F. Ceiling Membrane: Protect ceiling membrane per code. Fire caulk around openings. Provide listed radiation damper in rated roof/ceiling or floor/ceiling assemblies as required per code.
- G. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

3.2 GRILLES, REGISTERS AND DIFFUSERS INSTALLATION

- A. Coordinate with Architectural Reflected Ceiling Plan(s). Reflected ceiling plans determine final locations.
- B. Install diffusers to ductwork with air tight connection. 18-inch straight duct section or acoustic plenum at connection. Provide square to round adapters where required for connection to round ducts.
- C. Provide integral balancing dampers for diffusers, and grilles and registers where duct manual balancing dampers are not shown or specified.

END OF SECTION

This page intentionally left blank

HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Disposable Panel Filters

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.
- B. In addition, reference the following:
 - 1. Division 01, General Requirements, Temporary Facilities and Controls: Filters for temporary heating and ventilating.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. ASHRAE Std 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
 - 2. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
 - 3. UL 900 - Standard for Air Filter Units; Underwriters Laboratories Inc.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.
 - 2. Shop Drawings: Indicate filter assembly and filter frames, dimensions, motor locations, and electrical characteristics and connection requirements.

HVAC AIR CLEANING DEVICES

3. Manufacturer's Installation Instructions: Indicate assembly and change-out procedures.
4. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.
5. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - a. See Division 01, General Requirements for additional provisions.
 - b. Extra Filters: One set of each type and size.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 1. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 PERFORMANCE REQUIREMENTS

- A. Conform to ANSI/AHRI 850 I-P - Performance Rating of Commercial and Industrial Air Filter Equipment, Section 7.4.
 1. Dust Spot Efficiency: Plus or minus 5 percent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Filters:
 1. American Filtration Inc.
 2. AAF International/American Air Filter
 3. Camfil Farr Company
 4. Eco-Air Products
 5. Filtration Group

HVAC AIR CLEANING DEVICES

6. Flanders Corporation

2.2 DISPOSABLE PANEL FILTERS

- A. Media: UL 900 Class 2, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive.
 - 1. Nominal Size: 12- by 24-inches.
 - 2. Thickness: 2-inch.
- B. Performance Rating:
 - 1. Face Velocity: 500 FPM.
 - 2. Face Velocity: 350 FPM (2.54 m/sec).
 - 3. Initial Resistance: 0.15-inch WG.
 - 4. Recommended Final Resistance: 0.50-inches WG.
 - 5. MERV Rating: 8.
- C. Holding Frames: 20 gauge minimum galvanized steel frame with expanded metal grid on outlet side and steel rod grid on inlet side, hinged with pull and retaining handles.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Install air cleaning devices in accordance with manufacturer's instructions.
- B. Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.
- C. Operation During Construction: If air handlers are operated during construction, provide treated 2-inch media construction filter in front of prefilters and replace periodically to prevent dirt carryover. Install clean prefilters prior to air balancing.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.

3.2 SCHEDULES

- A. Air Filter Schedule
- B. Drawing Code
- C. Location
- D. Type

HVAC AIR CLEANING DEVICES

- E. Number
- F. Size
- G. Air Flow
- H. Face Velocity
- I. Overall Height
- J. Overall Width
- K. Initial Resistance
- L. Final Resistance

END OF SECTION

PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Indoor Packaged Energy Recovery Ventilators
 - a. Factory Testing
 - b. Cabinet
 - c. Blowers
 - d. Fixed Plate Heat Exchanger
 - e. Isolation Dampers
 - f. Bypass Damper
 - g. Filter
 - h. Pre-Heater
 - i. Electrical
 - j. Controls

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
1. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment (with Addendum 1).
 2. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils (with Addenda 1, 2 & 3).
 3. ANSI/AHRI Standard 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

4. AHRI 1060 I-P - Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment.
5. ASHRAE Standard 84 - Method of Testing Air-to-Air Heat/Energy Exchangers.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 1. Product Literature: Indicate dimensions, weights, capacities, ratings, gauges and finishes of materials, electrical characteristics and connection requirements.
 2. Certified fan performance curves with system operating conditions indicated.
 3. Certified fan sound-power ratings.
 4. Filters: Data for filter media, filter performance data.
 5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 1. Interior surfaces of units meet erosion and growth resistance requirements of ASHRAE 62.1, latest edition, as well as construction requirements for equipment.
 2. 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.
 3. Energy-Efficiency Ratio: Meet minimum requirements shown on Drawings.
 4. AHRI Certification: Provide AHRI certified and listed units.
 5. Sound Power Level Ratings: Comply with AHRI 270, Sound Performance Rating of Outdoor Unitary Equipment (with Addendum 1).
 6. Provide coils performing to AHRI 410 Standards.

PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

7. Entire unit to be ETL Certified per UL Standard 1995 and bear an ETL sticker.
8. Energy wheel to be AHRI 1060 I-P certified.
9. Performance: Scheduled capacities and face areas are minimum accepted values. Scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 EXTRA MATERIAL

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 INDOOR PACKAGED ENERGY RECOVERY VENTILATORS

- A. The following manufacturers will be considered provided they comply with Contract Documents:
 1. Daikin
 2. Mitsubishi
 3. LG
 4. Renewaire
- B. Factory Testing:
 1. The unit will be factory assembled, wired and run tested.
- C. Unit Cabinet:
 1. The cabinet will be fabricated of galvanized steel.
 2. Insulated with 2-inch-thick, 3/4-pound density, neoprene-coated glass fiber or polyurethane foam insulation.
- D. Blowers:
 1. Furnish with direct drive centrifugal blowers for supply and exhaust.

PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

2. Blower motors directly connected to the blower wheels and have permanently lubricated bearings.
 3. Blowers and motors mounted on isolators for quiet operation.
- E. Fixed Plate Heat Exchanger:
1. Heat exchanger element constructed of aluminum to allow sensible and latent energy recovery.
- F. Isolation Dampers:
1. Provide low leak insulated dampers on exhaust and outside air with actuators interlocked with fan operation.
- G. Bypass Damper:
1. The unit to have an automatic supply side bypass damper to allow inbound ventilation air to bypass the energy transfer core for economizer operation.
 2. Supply and return air thermistor will control the damper.
- H. Filter:
1. The heat exchanger will have protective filters installed at both the supply and exhaust sides with an access cover to allow easy maintenance.
 2. Provide MERV 8 filters.
- I. Pre-Heater:
1. Provide integral electric heater for frost protection.
- J. Electrical:
1. Unit wiring to comply with NEC requirements and applicable UL standards. Unit to have single point power terminal block for main power connection.
 2. The unit manufacturer to install power and control wiring.
 3. Provide ground fault detection.
- K. Controls:
1. Provide unit controller capable of stand-alone operation. Unit control system to perform unit control functions including scheduling, unit diagnostics and safeties. Unit controller, and sensors to be factory mounted, wired and tested.
 2. Provide external control from BMS.

PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

3. Controller provides the following functions:
 - a. Heat recovery mode: Ventilation air and exhaust air pass through energy recovery core and bypasses are closed.
 - b. Bypass mode: Outdoor air bypasses the core and is supplied from the unit.
 - c. Auto mode; automatically changes between the bypass and heat recovery modes based on space and outside air temperature.
 - d. Night purge.
 - e. Adjustable fan speed control.
 - f. Scheduling.

PART 3 - EXECUTION

3.1 INDOOR PACKAGED ENERGY RECOVERY VENTILATORS

- A. General Installation Requirements:
 1. Install in accordance with manufacturer's instructions.
 2. Use touch-up paint to repair scratches and minor damage to equipment prior to startup.
 3. Provide seismic restraint, as necessary.
 4. Install with required clearances and access for maintenance.
 5. Install factory furnished devices for field installation.
- B. Pre-Heater:
 1. Remove debris and clean heating elements.
- C. Electrical:
 1. Electrical System Connections: Comply with applicable requirements in Division 26, Electrical Sections for power wiring, switches, and motor controls.
 2. Ground equipment according to Division 26, Electrical.
 3. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- D. Controls:

PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

1. Connect to BMS.
- E. Field Quality Control:
1. Inspect for and remove shipping bolts, block and tie-down straps.
 2. After energizing units: Test units for proper fan rotation. Test and adjust controls and internal safeties.
 3. Replace malfunctioning units and retest.
 4. Thoroughly clean exposed portions of equipment. Install new filters prior to final test and balance and again prior to final acceptance.

END OF SECTION

AIR SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Split System Heat Pumps

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:

1. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment (with Addendum 1).
3. NRCA: Provide roof curbs in accordance with NRCA.

1.6 WARRANTY

- A. Warranty of materials and workmanship as outlined in Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:

1. Refrigeration Compressor(s) - 5-year warranty.

1.7 PACKAGED TERMINAL HEAT PUMP MOCK-UP

- A. Install one unit that includes inside cabinet, wall sleeve and wall louver.

AIR SOURCE HEAT PUMPS

- B. Locate where directed.
- C. Mock-up may remain as part of work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Split System Heat Pump:
 - 1. Indoor Air Handling Units:
 - a. Bryant
 - b. Lennox International
 - c. Rheem
 - d. Trane
 - e. York
 - f. LG
 - 2. Outdoor Air-Cooled Heat Pump Units:
 - a. Lennox International
 - b. Bryant
 - c. Rheem
 - d. Trane
 - e. York

2.2 SPLIT SYSTEM HEAT PUMP

- A. Indoor fan unit matched to outdoor heat pump unit. Self-contained, packaged, factory-assembled, pre-wired unit with direct expansion evaporator coil, cabinet supply fan, filter housing and controls. Accessories, economizer assembly, etc. as scheduled and shown on Drawings.
- B. Components:
 - 1. Steel cabinet with baked enamel finish; minimum 1/2-inch thick, 1-1/2# liner with cleanable facing or solid interior metal panel, filter housing suitable for 1-inch thick filter. Easily removed access panels.
 - 2. Mixing Box with outdoor air damper actuator.

AIR SOURCE HEAT PUMPS

- C. Refrigeration System: HFC Refrigerant or other refrigerant with zero ozone depletion potential (ODP).
- D. Air System:
 - 1. Supply Fan (Evaporator Fan): ECM motor drive with internal vibration isolation.
 - 2. Indoor Motor: Premium efficiency with permanently lubricated bearings thermal overload protection.
 - 3. Indoor Coil: Seamless copper tubes expanded into aluminum fins. Galvanized or polymer drain pan sloped in all directions.
 - 4. Filter: MERV 8, 1-inch thick, pleated, throw-away.
 - 5. Supplemental Heat Coil:
 - a. Electric Heat Coil: UL Listed with helix wound bare nichrome wire heating elements. Heat output and staging as scheduled. Power usage per stage is not to exceed 5 kilowatts. Staging of coil heat internally controlled.
- E. Condensate:
 - 1. Condensate pump kit.
 - 2. Secondary drain pan; Condensate overflow shut-off float switch and external alarm.
- F. Controls: Factory-wired to internal terminal strip or board for connection to programmable thermostat.
- G. Electrical: Furnish magnetic contactors. Arrange for single point electrical connection. Provide all associated field wiring.
- H. Outdoor Air-Cooled Heat Pump Units:
 - 1. Coils: Seamless copper tubes with copper or aluminum plate fins mechanically bonded to tubes.
 - 2. Fans: Direct driven, propeller type, arranged for vertical discharge, with safety guards. Motors: Permanently lubricated, on vibration isolators.
 - 3. Compressor: Serviceable hermetic design, with external spring isolators, automatically reversible oil pump, located in a section separated from condenser fans and coil. Provide low ambient controls to 20 degrees F.

AIR SOURCE HEAT PUMPS

4. Refrigerant: HFC refrigerant or other refrigerant with zero ozone depletion potential (ODP.)
 5. Controls: High- and low-pressure cut-out switches, compressor overload devices, anti-short cycle controls to prevent compressor from restarting for approximately five minutes after shutoff. Provide a transformer for control circuits. Provide automatic defrost controls that operate during heating, only when temperatures are below 36 degrees F, set to minimize energy use.
 6. Casing: Galvanized steel, designed for outdoor installation. Finished with baked enamel. Provide openings for power and refrigerant connections. Panel: Removable to provide access for servicing.
 7. Connections for liquid line, suction line, and power supply.
 8. Provide with low ambient kit for extended length piping.
- I. Outdoor Coil Defrost Control: Function on the basis of time and coil temperature. Timer to actuate a defrost mode if coil temperature is low enough to indicate frost condition. Defrost termination time maximum 10 minutes or when the defrost thermostat is satisfied. Electric resistance heaters operational automatically during the defrost cycle.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Examine areas and conditions under which units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Verify that ceiling system is ready to receive work and opening dimensions are as indicated on shop drawings.
- C. Verify that electric power is available and of the correct characteristics.
- D. Install in accordance with manufacturers written instructions and guidelines.
- E. Coordinate installation of unit with building components to allow adequate airflow to/from the units and for maintenance clearances. Mount outdoor units on a concrete housekeeping pad if on grade, or on a built-up roofing curb flashed and sealed in accordance with roofing warranty requirements.
- F. Provide adequate bracing and vibration isolation in accordance with seismic code requirements and acoustical engineers requirement.
- G. Provide adequate drainage connections and routing for condensate piping to indirect waste receiver.

AIR SOURCE HEAT PUMPS

- H. Provide shut off valves, site glasses, and routing pressure gauges, and all other appurtenances required for refrigerant system maintenance and operation.
- I. Provide filters for indoor units. Where outdoor units are installed, within 20 feet of trees, flowers plants, animals or other pollen or dander producing items, provide filters for outdoor units.
- J. Set initial temperature set points. Instruct operating personnel in adjustment of setpoints and controls.
- K. See Division 01, General Requirements and Section 23 00 00, HVAC Basic Requirements for additional requirements.
- L. Provide service and maintenance of units for one year from date of substantial completion.
- M. Furnish to Owner, with receipt, for each packaged heating and cooling unit:
 - 1. One set matched fan belts for each belt-driven fan.
 - 2. One set filters for each unit.

END OF SECTION

This page intentionally left blank

TERMINAL HEAT TRANSFER EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Electric Duct Heaters

1.2 RELATED SECTIONS

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

- A. Warranty of materials and workmanship as outlined in Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 ELECTRIC DUCT HEATERS

A. Manufacturers:

1. Indeeco
2. Markel
3. Dell Heatrix
4. Qmark
5. Chromalox
6. Nailor Industries

TERMINAL HEAT TRANSFER EQUIPMENT

7. Valley Industries
8. Warren
9. Electric duct heaters supplied as integral components of terminal units, heat pumps, etc. are acceptable.

B. Description:

1. Iron-free resistance wire, 80 percent nickel and 20 percent chromium, spaced no more than 4-inches apart with ceramic insulators and bushings, supported in aluminum steel frame suitable for duct installation. Test dielectrically for 1000V plus twice the rated voltage.
2. Housing: NEMA 1 construction of corrosion resistant steel with hinged, latching cover.
3. Power Control: Fully proportional SCR.
4. Control Voltage: 24 volts.
5. Safeties:
 - a. Overcurrent Protection: Built-in and prewired fuses with one overcurrent device for each 48 ampere circuit except with only one overcurrent device required for entire heater for those heaters rated 48 amperes or less. Fuses sized for available fault current with 20,000 AIC rating minimum. Supplier to coordinate with Division 26, Electrical.
 - b. Disc-type automatic reset thermal cutout for primary protection.
 - c. For secondary protection, furnish a sufficient number of heat elements in case the primary cutout fails.
 - d. Provide thermal cutout and heat limiters serviceable through the terminal box without removing the heater.
6. Terminal box with hinged, solid cover, duct mounted or remote as indicated on drawings.
7. Built-in Accessories: Factory wired with terminal blocks as required for field connections.
8. Contactors: Mercury-type to de-energize heater circuits; 3-pole line break for three phase and 1-pole break for single phase. Furnish a contactor for each heater circuit (step).

TERMINAL HEAT TRANSFER EQUIPMENT

9. Air Flow Switch: Pressure type to de-energize heater in the event of inadequate air flow. Switch located to function down to 25 percent of maximum air volume on discharge side of terminal unit.
 10. Transformer: With primary fuse protection to supply control voltage.
 11. Built-in disconnect switch.
 12. Frame Style: Flanged medium pressure application. Slip-in or flanged for low pressure application, suitable for lined ductwork.
 13. Provide a NEMA 4 weatherproof terminal box. Box to be all molded construction, complete with rustproof painted finish and gasketed cover with hold down clamps. Provide rigid insulation on back of the terminal box.
- C. Controls:
1. See Section 23 09 00, Instrumentation and Control Performance Specifications.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Avoid interference with structure and with work of other trades, preserving adequate headroom and clearing doors and passageways. Check each piece of equipment for defects, verifying that items function properly and that adjustments have been made.
- B. Prior to acceptance, thoroughly clean exposed portions of terminal heat transfer equipment, remove shipping labels and traces of foreign substance. Touch up scratched surfaces of radiant panels with factory matching paint.

3.2 ELECTRIC DUCT HEATERS INSTALLATION

- A. Damaged Coils: Make every effort to prevent damage to both built-up coils and coils of packaged equipment. Comb damaged coil fins to be straight.
- B. Support units rigidly from structure. Seal air tight around frame.
- C. Provide access to each side of elements.
- D. Electric coils to comply with voltage, wattage, number of steps and accessories as indicated, and installed in uniform air flow entering and leaving.
- E. Provide controls that are completely accessible as installed.

END OF SECTION

This page intentionally left blank

ELECTRICAL BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Work included in 26 00 00, Electrical Basic Requirements applies to Division 26, Electrical work to provide materials, labor, tools, permits, incidentals, and other services to provide and make ready for Owner's use of electrical systems for proposed project.
- B. Contract Documents include, but are not limited to, Specifications including Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Drawings, Addenda, Owner/Architect Agreement, and Owner/Contractor Agreement. Confirm requirements before commencement of work.
- C. Definitions:
 - 1. Provide: To furnish and install, complete and ready for intended use.
 - 2. Furnish: Supply and deliver to project site, ready for unpacking, assembly and installation.
 - 3. Install: Includes unloading, unpacking, assembling, erecting, installation, applying, finishing, protecting, cleaning and similar operations at project site as required to complete items of work furnished.
 - 4. Approved or Approved Equivalent: To possess the same performance qualities and characteristics and fulfill the utilitarian function without any decrease in quality, durability or longevity. For equipment/products defined by the Contractor as "equivalent", substitution requests must be submitted to Engineer for consideration, in accordance with Division 01, General Requirements, and approved by the Engineer prior to submitting bids for substituted items.
 - 5. Authority Having Jurisdiction (AHJ): Indicates reviewing authorities, including local fire marshal, Owner's insurance underwriter, Owner's Authorized Representative, and other reviewing entity whose approval is required to obtain systems acceptance.

1.2 RELATED SECTIONS

- A. Contents of Section applies to Division 26, Electrical Contract Documents.
- B. Related Work:
 - 1. Additional conditions apply to this Division including, but not limited to:
 - a. Specifications including Division 00, Procurement and Contracting Requirements and Division 01, General Requirements.
 - b. Drawings

ELECTRICAL BASIC REQUIREMENTS

- c. Addenda
- d. Owner/Architect Agreement
- e. Owner/Contractor Agreement
- f. Codes, Standards, Public Ordinances and Permits

1.3 REFERENCES AND STANDARDS

- A. References and Standards per Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, individual Division 26, Electrical Sections and those listed in this Section.
- B. Codes to include latest adopted editions, including current amendments, supplements and local jurisdiction requirements in effect as of the date of the Contract Documents, of/from:
 - 1. State of Oregon:
 - a. OAR - Oregon Administrative Rules
 - b. 2021 OESC - Oregon Electrical Specialty Code
 - c. 2019 OFC - Oregon Fire Code
 - d. 2019 OMSC - Oregon Mechanical Specialty Code
 - e. 2021 OPSC - Oregon Plumbing Specialty Code
 - f. 2019 OSSC - Oregon Structural Specialty Code
 - g. 2021 OEESC - Oregon Energy Efficiency Specialty Code
 - h. 2011 Oregon Elevator Specialty Code
- C. Reference standards and guidelines include but are not limited to the latest adopted editions from:
 - 1. ABA - Architectural Barriers Act
 - 2. ADA - Americans with Disabilities Act
 - 3. ANSI - American National Standards Institute
 - 4. APWA - American Public Works Association
 - 5. ASCE - American Society of Civil Engineers
 - 6. ASHRAE Guideline 0, the Commissioning Process

ELECTRICAL BASIC REQUIREMENTS

7. ASTM - ASTM International
 8. CFR - Code of Federal Regulations
 9. EPA - Environmental Protection Agency
 10. ETL - Electrical Testing Laboratories
 11. FCC - Federal Communications Commission
 12. FM - FM Global
 13. IBC - International Building Code
 14. IEC - International Electrotechnical Commission
 15. IEEE - Institute of Electrical and Electronics Engineers
 16. IES - Illuminating Engineering Society
 17. ISO - International Organization for Standardization
 18. MSS - Manufacturers Standardization Society
 19. NEC - National Electric Code
 20. NECA - National Electrical Contractors Association
 21. NEMA - National Electrical Manufacturers Association
 22. NETA - National Electrical Testing Association
 23. NFPA - National Fire Protection Association
 24. OSHA - Occupational Safety and Health Administration
 25. UL - Underwriters Laboratories Inc.
- D. See Division 26, Electrical individual Sections for additional references.
- 1.4 SUBMITTALS
- A. See Division 01, General Requirements for Submittal Procedures as well as individual Division 26, Electrical Sections.
 - B. Provide drawings in format and software release equal to the design documents. Drawings to be the same sheet size and scale as the Contract Documents.
 - C. In addition:

ELECTRICAL BASIC REQUIREMENTS

1. "No Exception Taken" constitutes that review is for general conformance with the design concept expressed in the Contract Documents for the limited purpose of checking for conformance with information given. Any action is subject to the requirements of the Contract Documents. Contractor is responsible for the dimensions and quantity and will confirm and correlate at the job site, fabrication processes and techniques of construction, coordination of the work with that of all other trades, and the satisfactory performance of the work.
2. Provide product submittals and shop drawings in electronic format only. Electronic format must be posted to ftp site. For electronic format, provide one file per division containing one bookmarked PDF file with each bookmark corresponding to each Specification Section. Arrange bookmarks in ascending order of Specification Section number. Individual submittals sent piecemeal in a per Specification Section method will be returned without review or comment. All transmissions/submissions to be submitted to Architect. Deviations will be returned without review.
 - a. Provide separate submittals for lighting control cutsheets, and for lighting control shop drawings.
3. Product Data: Provide manufacturer's descriptive literature for products specified in Division 26, Electrical Sections.
4. Identify/mark each submittal in detail. Note what differences, if any, exist between the submitted item and the specified item. Failure to identify the differences will be considered cause for disapproval. If differences are not identified and/or not discovered during the submittal review process, Contractor remains responsible for providing equipment and materials that meet the Specifications and Drawings.
 - a. Label submittal to match numbering/references as shown in Contract Documents. Highlight and label applicable information to individual equipment or cross out/remove extraneous data not applicable to submitted model. Clearly note options and accessories to be provided, including field installed items. Highlight connections by/to other trades.
 - b. Include technical data, installation instructions and dimensioned drawings for products, fixtures, equipment and devices installed, furnished or provided. Reference individual Division 26, Electrical specification Sections for specific items required in product data submittal outside of these requirements.
 - c. See Division 26, Electrical individual Sections for additional submittal requirements outside of these requirements.

ELECTRICAL BASIC REQUIREMENTS

5. Maximum of two reviews of complete submittal package. Arrange for additional reviews and/or early review of long-lead items; Bear costs of these additional reviews at Engineer's hourly rates. Incomplete submittal packages/submittals will be returned to contractor without review.
6. Resubmission Requirements: Make corrections or changes in submittals as required, and in consideration of Engineer's comments. Identify Engineer's comments and provide an individual response to each of the Engineer's comments. Cloud changes in the submittals and further identify changes which are in response to Engineer's comments.
7. Structural/Seismic: Provide weights, dimensions, mounting requirements and like information required for mounting, seismic bracing, and support. Indicate manufacturer's installation and support requirements to meet ASCE 7-16 requirements for non-structural components. Provide engineered seismic drawings and equipment seismic certification. Equipment Importance Factor as specified in Division 01 and in Structural documents.
8. Trade Coordination: Include physical characteristics, electrical characteristics, device layout plans, wiring diagrams, and connections as required per Division 26, Electrical Coordination Documents. For equipment with electrical connections, furnish copy of approved submittal for inclusion in Division 26, Electrical submittals. Electric motors are supplied and installed by Division 23 unless otherwise specified. During shop drawing stage of the project, verify correct disconnect sizes, conductor sizes, etc., and bring any discrepancies to the attention of the Mechanical trade. Be responsible for any modifications to electrical equipment or installations as a result of equipment incompatibility discovered after shop drawing review.
9. Make provisions for openings in building for admittance of equipment prior to start of construction or ordering of equipment.
10. Substitutions and Variation from Basis of Design:
 - a. The Basis of Design designated product establishes the qualities and characteristics for the evaluation of any comparable products by other listed acceptable manufacturers if included in this Specification or included in an approved Substitution Request as judged by the Design Professional.
 - b. If substitutions and/or equivalent equipment/products are being proposed, it is the responsibility of parties concerned, involved in, and furnishing the substitute and/or equivalent equipment to verify and compare the characteristics and requirements of that furnished to that specified and/or shown. If greater capacity and/or more materials and/or

ELECTRICAL BASIC REQUIREMENTS

more labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then provide compensation for additional charges required for the proper rough-in, circuitry and connections for the equipment being furnished. No additional charges above the Base Bid, including resulting charges for work performed under other Divisions, will be allowed for such revisions. Coordinate with the requirements of "Submittals". For any product marked "or approved equivalent", a substitution request must be submitted to Engineer for approval prior to purchase, delivery or installation.

11. Shop Drawings: Provide coordinated shop drawings which include physical characteristics of all systems, device layout plans, and control wiring diagrams. Reference individual Division 26, Electrical specification Sections for additional requirements for shop drawings outside of these requirements.
 - a. Provide Shop Drawings indicating access panel locations, size and elevation for approval prior to installation.
12. Samples: Provide samples when requested by individual Sections.
13. Resubmission Requirements:
 - a. Make any corrections or change in submittals when required. Provide submittals as specified. The Engineer will not be required to edit and/or interpret the Contractor's submittals. Indicate changes for the resubmittal in a cover letter with reference to page(s) changed and reference response to comment. Cloud changes in the submittals.
 - b. Resubmit for review until review indicates no exception taken or "make corrections as noted".
14. Operation and Maintenance Manuals, Owner's Instructions:
 - a. Submit, at one time, electronic files (PDF format) of manufacturer's operation and maintenance instruction manuals and parts lists for equipment or items requiring servicing. Submit data when work is substantially complete and in same order format as submittals. Include name and location of source parts and service for each piece of equipment.
 - (1) Include copy of approved submittal data along with submittal review letters received from Engineer. Data to clearly indicate installed equipment model numbers. Delete or cross out data pertaining to other equipment not specific to this project.

ELECTRICAL BASIC REQUIREMENTS

- (2) Include copy of manufacturer's standard Operations and Maintenance for equipment. At front of each tab, provide routine maintenance documentation for scheduled equipment. Include manufacturer's recommended maintenance schedule and highlight maintenance required to maintain warranty. Furnish list of routine maintenance parts, including part numbers, sizes, quantities, relevant to each piece of equipment.
 - (3) Include Warranty per Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
 - (4) Include product certificates of warranties and guarantees.
 - (5) Include copy of complete parts list for equipment. Include available exploded views of assemblies and sub assemblies.
 - (6) Include commissioning reports.
 - (7) Include copy of startup and test reports specific to each piece of equipment.
 - (8) Engineer will return incomplete documentation without review. Engineer will provide one set of review comments in Submittal Review format. Contractor must arrange for additional reviews; Contractor to bear costs for additional reviews at Engineer's hourly rates.
- b. Thoroughly instruct Owner in proper operation of equipment and systems. Where noted in individual Sections, training will include classroom instruction with applicable training aids and systems demonstrations. Field instruction per Section 26 00 00, Electrical Basic Requirements, Demonstration.
 - c. Copies of certificates of code authority inspections, acceptance, code required acceptance tests, and other special guarantees, certificates of warranties, specified elsewhere or indicated on Drawings.
15. Record Drawings:
- a. Maintain at site at least one set of drawings for recording "As-constructed" conditions. Indicate on drawings changes to original documents by referencing revision document, and include buried elements, location of conduit, and location of concealed electrical items. Include items changed by field orders, supplemental instructions, and

ELECTRICAL BASIC REQUIREMENTS

constructed conditions.

- b. Record Drawings are to include equipment and fixture/connection schedules that accurately reflect "as constructed or installed" for project.
- c. At completion of project, input changes to original project on CAD Drawings and make one set of black-line drawings created from CAD Files in version/release equal to contract drawings. Submit CAD Files and drawings upon substantial completion.
- d. At completion of project, show changes and deviations from the Drawings in red on one set of black-line drawings. Include written Addendums, RFIs, and change order items. Make changes to Drawings in a neat, clean, and legible manner.
- e. See Division 26, Electrical individual Sections for additional items to include in record drawings.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Work and materials installed to conform with all local, State and Federal codes, and other applicable laws and regulations. Where code requirements are at variance with Contract Documents, meet code requirements as a minimum requirement and include costs necessary to meet these in Contract. Machinery and equipment are to comply with OSHA requirements, as currently revised and interpreted for equipment manufacturer requirements. Install equipment provided per manufacturer recommendations.
- B. Whenever this Specification calls for material, workmanship, arrangement or construction of higher quality and/or capacity than that required by governing codes, higher quality and/or capacity take precedence.
- C. Drawings are intended to be diagrammatic and reflect the Basis of Design manufacturer's equipment. They are not intended to show every item in its exact dimensions, or details of equipment or proposed systems layout. Verify actual dimensions of systems (i.e. distribution equipment, duct banks, light fixtures, etc.) and equipment proposed to assure that systems and equipment will fit in available space. Contractor is responsible for design and construction costs incurred for equipment other than Basis of Design, including, but not limited to, architectural, structural, electrical, HVAC, fire sprinkler, and plumbing systems.
- D. Manufacturer's Instructions: Follow manufacturer's written instructions. If in conflict with Contract Documents, obtain clarification. Notify Engineer/Architect, in writing, before starting work.

ELECTRICAL BASIC REQUIREMENTS

- E. Items shown on Drawings are not necessarily included in Specifications or vice versa. Confirm requirements in all Contract Documents.
- F. Provide products that are UL listed.

1.6 WARRANTY

- A. Provide written warranty covering the work for a period of one year from date of Substantial Completion in accordance with Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
- B. Sections under this Division can require additional and/or extended warranties that apply beyond basic warranty under Division 01, General Requirements and the General Conditions. Confirm requirements in all Contract Documents.

1.7 COORDINATION DOCUMENTS

- A. Prior to construction, coordinate installation and location of HVAC equipment, ductwork, grilles, diffusers, piping, plumbing equipment/fixtures, fire sprinklers, plumbing, lights, cable tray and electrical services with architectural and structural requirements, and other trades (including ceiling suspension and tile systems), and provide maintenance access requirements. Coordinate with submitted architectural systems (i.e. roofing, ceiling, finishes) and structural systems as submitted, including footings and foundation. Identify zone of influence from footings and ensure systems are not routed within the zone of influence.
- B. Advise Architect in event a conflict occurs in location or connection of equipment. Bear costs resulting from failure to properly coordinate installation or failure to advise Architect of conflict.
- C. Submit final Coordination Drawings with changes as Record Drawings at completion of project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Articles, fixtures, and equipment of a kind to be standard product of one manufacturer.

2.2 STANDARDS OF MATERIALS AND WORKMANSHIP

- A. Base contract upon furnishing materials as specified. Materials, equipment, and fixtures used for construction are to be new, latest products as listed in manufacturer's printed catalog data and are to be UL or ETL listed and labeled or be approved by State, County, and City authorities prior to procurement and installation.

ELECTRICAL BASIC REQUIREMENTS

- B. Names and manufacturer's names denote character and quality of equipment desired and are not to be construed as limiting competition.
- C. Hazardous Materials:
 - 1. Comply with local, State of Oregon, and Federal regulations relating to hazardous materials.
 - 2. Comply with Division 00, Procurement and Contracting Requirements and Division 01, General Requirements for this project relating to hazardous materials.
 - 3. Do not use any materials containing a hazardous substance. If hazardous materials are encountered, do not disturb; immediately notify Owner and Architect. Hazardous materials will be removed by Owner under separate contract.

2.3 ACCESS PANELS

- A. See Division 01, General Requirements and Division 08, Openings for products and installation requirements.
- B. Confirm Access Panel requirements in Division 01, General Requirements, Division 08, Openings and individual Division 26, Electrical Sections. In the absence of specific requirements, comply with the following:
 - 1. Provide flush mounting access panels for service of systems and individual components requiring maintenance or inspection. Where access panels are located in fire-rated assemblies of building, rate access panels accordingly.
 - a. Ceiling access panels to be minimum of 24-inch by 24-inch.
 - b. Wall access panels to be minimum of 12-inch by 12-inch.
 - c. Provide screwdriver operated catch.
 - d. Manufacturers and Models:
 - (1) Drywall: Karp KDW.
 - (2) Plaster: Karp DSC-214PL.
 - (3) Masonry: Karp DSC-214M.
 - (4) 2 hour rated: Karp KPF-350FR.
 - (5) Manufacturers: Milcor, Elmdor, Acudor, or approved equivalent.

ELECTRICAL BASIC REQUIREMENTS

PART 3 - EXECUTION

3.1 ACCESSIBILITY AND INSTALLATION

- A. Confirm Accessibility and Installation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
- B. Install equipment requiring access (i.e., junction boxes, light fixtures, power supplies, motors, etc.) so that they may be serviced, reset, replaced or recalibrated by service people with normal service tools and equipment. Do not install equipment in passageways, doorways, scuttles or crawlspaces which would impede or block the intended usage.
- C. Install equipment and products complete as directed by manufacturer's installation instructions. Obtain installation instructions from manufacturer prior to rough-in of equipment and examine instructions thoroughly. When requirements of installation instructions conflict with Contract Documents, request clarification from Architect and Engineer prior to proceeding with installation. This includes proper installation methods, sequencing, and coordination with other trades and disciplines.
- D. Earthwork:
 - 1. Confirm Earthwork requirements in Contract Documents. In the absence of specific requirements, comply with individual Division 26, Electrical Sections and the following:
 - a. Perform excavation, dewatering, shoring, bedding, and backfill required for installation of work in this Division in accordance with related earthwork Sections. Contact utilities and locate existing utilities prior to excavation. Repair any work damaged during excavation or backfilling.
 - b. Excavation: Do not excavate under footings, foundation bases, or retaining walls.
 - c. Provide protection of underground systems. Review the project Geotechnical Report for references to corrosive or deleterious soils which will reduce the performance or service life of underground systems materials.
- E. Firestopping:
 - 1. Confirm requirements in Division 07, Thermal and Moisture Protection. In the absence of specific requirements, comply with individual Division 26, Electrical Sections and the following:

ELECTRICAL BASIC REQUIREMENTS

- a. Coordinate location and protection level of fire and/or smoke rated walls, ceilings, and floors. When these assemblies are penetrated, seal around piping and equipment with approved firestopping material. Install firestopping material complete as directed by manufacturer's installation instructions. Meet requirements of ASTM E814, Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
- F. Plenums:
1. In plenums, provide plenum rated materials that meet the requirements to be installed in plenums. Immediately notify Architect/Engineer of discrepancy.
- G. Start up equipment, in accordance with manufacturer's start-up instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- H. Provide miscellaneous supports/metals required for installation of equipment and conduit.

3.2 SEISMIC CONTROL

- A. Confirm Seismic Control requirements in Division 01, General Requirements, Structural documents, and individual Division 26 Electrical Sections.
- B. General:
1. Earthquake resistant designs for Electrical (Division 26) equipment and distribution, i.e. power distribution equipment, generators, UPS, etc. to conform to regulations of jurisdiction having authority.
 2. Restraints which are used to prevent disruption of function of piece of equipment because of application of horizontal force to be such that forces are carried to frame of structure in such a way that frame will not be deflected when apparatus is attached to a mounting base and equipment pad, or to structure in normal way, utilizing attachments provided. Secure equipment and distribution systems to withstand a force in direction equal to value defined by jurisdiction having authority.
 3. Provide stamped shop drawings from licensed Structural Engineer of seismic bracing and seismic movement assemblies for conduit and equipment. Submit shop drawings along with equipment submittals.
 4. Provide stamped shop drawings from licensed Structural Engineer of seismic flexible joints for conduit crossing building expansion or seismic joints. Submit shop drawings along with seismic bracing details.
 5. Provide means to prohibit excessive motion of electrical equipment during earthquake.

ELECTRICAL BASIC REQUIREMENTS

3.3 REVIEW AND OBSERVATION

- A. Confirm Review and Observation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
- B. Notify Architect or Engineer, in writing, at following stages of construction so that they may, at their option, visit site for review and construction observation:
 - 1. Underground conduit installation prior to backfilling.
 - 2. Prior to covering walls.
 - 3. Prior to ceiling cover/installation.
 - 4. When main systems, or portions of, are being tested and ready for inspection by AHJ.
- C. Final Punch:
 - 1. Prior to requesting a final punch visit from the Engineer, request from Engineer the Electrical Precloseout Checklist, complete the checklist confirming completion of systems' installation, and return to Engineer. Request a final punch visit from the Engineer, upon Engineer's acceptance that the electrical systems are ready for final punch.
 - 2. Costs incurred by additional trips required due to incomplete systems will be the responsibility of the Contractor.

3.4 CONTINUITY OF SERVICE

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements, and Division 01, General Requirements. In the absence of specific requirements in Division 01, General Requirements, comply with individual Division 26, Electrical Sections and the following:
 - 1. During remodeling or addition to existing structure, while existing structure is occupied, present services to remain intact until new construction, facilities or equipment is installed.
 - 2. Prior to changing over to new service, verify that every item is thoroughly prepared. Install new wiring, and wiring to point of connection.
 - 3. Coordinate transfer time to new service with Owner. If required, perform transfer during off-peak hours. Once changeover is started, pursue to its completion to keep interference to a minimum.

ELECTRICAL BASIC REQUIREMENTS

- a. If overtime is necessary, there will be no allowance made by Owner for extra expense for such overtime or shift work.
4. No interruption of services to any part of existing facilities will be permitted without express permission in each instance from Owner. Requests for outages must state specific dates, hours and maximum durations, with outages kept to these specific dates, hours and maximum durations. Obtain written permission from Owner for any interruption of power, lighting or signal circuits and systems.
 - a. Organize work to minimize duration of power interruption.
 - b. Coordinate utility service outages with utility company.

3.5 CUTTING AND PATCHING

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In the absence of specific requirements in Division 01, General Requirements, comply with individual Division 26, Electrical Sections and the following:
 1. Proposed floor cutting/core drilling/sleeve locations to be approved by Project Structural Engineer. Submit proposed locations to Architect/Project Structural Engineer. Where slabs are of post tension construction, perform x-ray scan of proposed penetration locations and submit scan results including proposed penetration locations to Project Structural Engineer/Architect for approval. Where slabs are of waffle type construction, show column cap extent and cell locations relative to proposed penetration(s).
 2. Cutting, patching and repairing for work specified in this Division including plastering, masonry work, concrete work, carpentry work, and painting included under this Section will be performed by skilled craftspeople of each respective trade in conformance with appropriate Division of Work.
 3. Additional openings required in building construction to be made by drilling or cutting. Use of jack hammer is specifically prohibited. Patch openings in and through concrete and masonry with grout.
 4. Restore new or existing work that is cut and/or damaged to original condition. Patch and repair specifically where existing items have been removed. This includes repairing and painting walls, ceilings, etc. where existing conduit and devices are removed as part of this project. Where alterations disturb lawns, paving, and/or walks, surfaces to be repaired, refinished and left in condition matching existing prior to commencement of work.
 5. Additional work required by lack of proper coordination will be provided at no additional cost to the Owner.

ELECTRICAL BASIC REQUIREMENTS

3.6 EQUIPMENT SELECTION AND SERVICEABILITY

- A. Replace or reposition equipment which is too large or located incorrectly to permit servicing, at no additional cost to Owner.

3.7 DELIVERY, STORAGE AND HANDLING

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In the absence of specific requirements, comply with individual Division 26, Electrical Sections and the following:
 - 1. Handle materials delivered to project site with care to avoid damage. Store materials on site inside building or protected from weather, dirt and construction dust. Products and/or materials that become damaged due to water, dirt, and/or dust as a result of improper storage and handling to be replaced before installation.
 - 2. Protect equipment to avoid damage. Close conduit openings with caps or plugs. Keep motors and bearings in watertight and dustproof covers during entire course of installation.
 - 3. Protect bus duct and similar items until in service.

3.8 DEMONSTRATION

- A. Confirm Demonstration requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, and individual Division 26, Electrical Sections.
- B. Upon completion of work and adjustment of equipment, test systems and demonstrate to Owner's Authorized Representative, Architect, and Engineer that equipment furnished and installed or connected under provisions of these Specifications functions in manner required. Provide field instruction to Owner's Maintenance Staff as specified in Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
- C. Manufacturer's Field Services: Furnish services of a qualified person at time approved by Owner, to instruct maintenance personnel, correct defects or deficiencies, and demonstrate to satisfaction of Owner that entire system is operating in satisfactory manner and complies with requirements of other trades that may be required to complete work. Complete instruction and demonstration prior to final job site observations.

3.9 CLEANING

- A. Confirm Cleaning requirements in Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.

ELECTRICAL BASIC REQUIREMENTS

- B. Upon completion of installation, thoroughly clean electrical equipment, removing dirt, debris, dust, temporary labels and traces of foreign substances. Throughout work, remove construction debris and surplus materials accumulated during work.

3.10 INSTALLATION

- A. Confirm Installation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
- B. Install equipment and fixtures in accordance with manufacturers' installation instructions, plumb and level and firmly anchored to vibration isolators. Maintain manufacturer's recommended clearances.
- C. Start up equipment, in accordance with manufacturer's start-up instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- D. Provide miscellaneous supports/metals required for installation of equipment.

3.11 PAINTING

- A. Confirm requirements in Division 01, General Requirements and Division 09, Finishes. In the absence of specific requirements, comply with individual Division 26, Electrical Sections and the following:
 - 1. Ferrous Metal: After completion of work, thoroughly clean and paint exposed supports constructed of ferrous metal surfaces (i.e., hangers, hanger rods, equipment stands, etc.) with one coat of black asphalt varnish for exterior or black enamel for interior, suitable for hot surfaces.
 - 2. In Electrical Room, on roof or other exposed areas, equipment not painted with enamel to receive two coats of primer and one coat of rustproof enamel, colors as selected by Architect.
 - 3. See individual equipment Specifications for other painting.
 - 4. Structural Steel: Repair damage to structural steel finishes or finishes of other materials damaged by cutting, welding or patching to match original.
 - 5. Conduit: Clean, primer coat and paint interior/exterior conduit exposed in public areas with two coats paint suitable for metallic surfaces. Color selected by Architect.
 - 6. Covers: Covers such as manholes, vaults and the like will be furnished with finishes which resist corrosion and rust.

ELECTRICAL BASIC REQUIREMENTS

3.12 ACCESS PANELS

- A. Confirm Access Panel requirements in Division 01, General Requirements. In the absence of specific requirements in Division 01, General Requirements, comply with individual Division 26, Electrical Sections and the following:
1. Coordinate locations/sizes of access panels with Architect prior to work.

3.13 DEMOLITION

- A. Confirm requirements in Division 01, General Requirements and Division 02, Existing Conditions. In the absence of specific requirements, comply with individual Division 26, Electrical Sections and the following:
1. It is the intent of these documents to provide necessary information and adjustments to electrical system required to meet code, and accommodate installation of new work.
 2. Coordinate with Owner so that work can be scheduled not to interrupt operations, normal activities, building access or access to different areas. Owner will cooperate to best of their ability to assist in coordinated schedule, but will remain final authority as to time of work permitted.
 3. Examination:
 - a. Determine exact location of existing utilities and equipment before commencing work, compensate Owner for damages caused by failure to locate and preserve utilities. Replace damaged items with new material to match existing.
 - b. Verify that abandoned wiring and equipment serve only abandoned facilities.
 - c. Demolition drawings are based on casual field observation and existing record documents.
 - (1) Verify accuracy of information shown prior to bidding and provide such labor and material as is necessary to accomplish work.
 - (2) Verify location and number of electrical outlets, luminaires, panels, etc. in field.
 - d. Report discrepancies to Architect before disturbing existing installation.
 - (1) Promptly notify Owner if utilities are found which are not shown on Drawings.

ELECTRICAL BASIC REQUIREMENTS

4. Execution:
 - a. Remove existing luminaires, switches, receptacles, and other electrical equipment and devices and associated wiring from walls, ceilings, floors, and other surfaces scheduled for remodeling, relocation, or demolition unless shown as retained or relocated on Drawings.
 - b. Provide temporary wiring and connections to maintain electrical continuity of existing systems during construction. Remove or relocate electrical boxes, conduit, wiring, equipment, and luminaires, as encountered in removed or remodeled areas in existing construction affected by this work.
 - c. Remove and restore wiring which serves usable existing outlets clear of construction or demolition.
 - d. If existing junction boxes will be made inaccessible, or if abandoned outlets serve as feed through boxes for other existing electrical equipment which is being retained, provide new conduit and wire to bypass inaccessible junction boxes and abandoned outlets.
 - e. If existing conduits pass through partitions or ceiling which are being removed or remodeled, provide new conduit and wire to reroute clear of construction or demolition and maintain service to existing load.
 - f. Extend circuiting and devices in existing walls to be furred out.
 - g. Remove abandoned wiring to source of supply.
 - h. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
 - i. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.
 - j. Disconnect and remove abandoned panelboards and distribution equipment.
 - k. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
 - l. Existing lighting which is to remain, leave luminaires in proper working order.

ELECTRICAL BASIC REQUIREMENTS

- m. Repair adjacent construction and finishes damaged during demolition work.
- n. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

3.14 ACCEPTANCE

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In the absence of specific requirements, comply with individual Division 26, Electrical Sections and the following:
 - 1. System cannot be considered for acceptance until work is completed and demonstrated to Architect that installation is in strict compliance with Specifications, Drawings and manufacturer's installation instructions, particularly in reference to following:
 - a. Cleaning
 - b. Operation and Maintenance Manuals
 - c. Training of Operating Personnel
 - d. Record Drawings
 - e. Warranty and Guaranty Certificates
 - f. Start-up/Test Document and Commissioning Reports

3.15 FIELD QUALITY CONTROL

- A. Confirm Field Quality Control requirements in Division 01, General Requirements, Section 26 00 00, Electrical Basic Requirements and individual Division 26, Electrical Sections.
- B. Tests:
 - 1. Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Reference individual Specification Sections for required tests. Document tests and include in operation and maintenance manuals.
 - 2. During site evaluations by Architect or Engineer, provide appropriate personnel with tools to remove and replace trims, covers, and devices so that proper evaluation of installation can be performed.

3.16 SALVAGED EQUIPMENT AND RECYCLED MATERIAL

- A. Salvage the following equipment not being reused and return to Owner:

ELECTRICAL BASIC REQUIREMENTS

1. Breakers
- B. Electrical equipment that cannot be salvaged for reuse, sell/give to recycling company. Recycle following excess, removed, or demolished electrical material:
1. Copper or aluminum conductors, buses, and motor/transformer windings.
 2. Steel and aluminum from raceways, boxes, enclosures, and housings.
 3. Acrylic and glass from luminaire lenses/refractors.
- C. Provide separate on-site storage space for recycled and salvaged material. Clearly label space.
- D. Confirm additional salvaged equipment and recycled materials in the Contract Documents.

END OF SECTION

EQUIPMENT WIRING

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Equipment connections, whether furnished by Owner or other Divisions of the Contract.

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

B. In addition:

1. Verify mechanical and utilization equipment electrical characteristics with Drawings and equipment submittals prior to ordering equipment. Submit confirmation of this verification as a part of, or addendum to, the electrical product submittals.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements apply to this Section.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials and Equipment for Equipment Wiring: As specified in individual Sections.

EQUIPMENT WIRING

2.2 GENERAL

- A. Unless otherwise noted, the following voltage and phase characteristics apply to motors:
 - 1. 3/4 HP and Under: 120 volt, 1 phase.
 - 2. 1 HP and Less than 5 HP Loads: 240 volt, 3 phase.
 - 3. 5 HP and Over: 240 volt, 3 phase.
- B. Safety Switches: Provide as required by NEC and as specified in Section 26 28 16, Enclosed Switches and Circuit Breakers.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to submittal of product data for electrical distribution equipment, obtain and examine product data and shop drawings for equipment furnished by the Owner and by other trades on the project. Update the schedule of equipment electrical connections accordingly, noting proper ratings for overcurrent devices, fuses, safety disconnect switches, conduit and wiring, and the like. As a minimum, this requirement applies to equipment furnished by Owner and equipment furnished under the following divisions of work under this contract:
 - 1. Division 8, Openings
 - 2. Division 11, Equipment
 - 3. Division 22, Plumbing
 - 4. Division 23, HVAC, Heating, Ventilating and Air Conditioning

3.2 INSTALLATION

- A. Do not install unrelated electrical equipment or wiring on mechanical equipment without prior approval of Engineer.
- B. Provide moisture tight equipment wiring and switches in ducts or plenums used for environmental air.
- C. Connect motor and appliance/utilization equipment complete from panel to motor/equipment as required by code.
- D. Install motor starters and controllers for equipment furnished by others.
- E. Appliance/Utilization Equipment:

EQUIPMENT WIRING

1. Provide appropriate cable and cord cap for final connection unless equipment is provided with same. Provide receptacle configured to receive cord cap.
2. Verify special purpose outlet NEMA configuration and ampere rating with equipment supplier prior to ordering wiring devices and coverplates.

3.3 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Division 01, General Requirements.

3.4 SYSTEMS STARTUP

- A. Provide field representative to prepare and start equipment.
 1. Test and correct for proper rotation of polyphase motors.
- B. Adjust for proper operation within manufacturer's published tolerances.
- C. Demonstrate proper operation of equipment to Owner's Authorized Representative.

END OF SECTION

This page intentionally left blank

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Lugs and Pads
 - 2. Wires and Cables
 - 3. Connectors

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
 - 1. Cable insulation test reports in project closeout documentation.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Lugs and Pads:
 - 1. Anderson
 - 2. Ilsco

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

3. Panduit
 4. Thomas & Betts
 5. 3M
 6. Or approved equivalent.
- B. Wires and Cables:
1. General:
 - a. General Cable
 - b. Okonite
 - c. Southwire
 - d. Encore Wire
 - e. Or approved equivalent.
 2. Metal Clad Cable - Type MC:
 - a. Alflex
 - b. AFC
 - c. General Cable
 - d. Southwire
 - e. Encore Wire
 - f. Or approved equivalent.
- C. Connectors:
1. Anderson Power Products
 2. Burndy
 3. Ilsco
 4. 3M
 5. Thomas & Betts
 6. Or approved equivalent.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

2.2 LUGS AND PADS

- A. Ampacity: Cross-sectional area of pad for multiple conductor terminations to match ampere rating of panelboard bus or equipment line terminals.
- B. Copper Pads: Drilled and tapped for multiple conductor terminals.
- C. Lugs: Compression type for use with stranded branch circuit or control conductors; mechanical type for use with solid branch and feeder circuit conductors.

2.3 WIRES AND CABLES

- A. Building Wires:
 - 1. Copper: Soft-drawn with conductivity of not less than 98 percent IACS at 20 degrees C (68 degrees F). 600 volt rated throughout. Conductors 12 AWG and 10 AWG, solid or stranded. Conductors 8 AWG and larger, stranded. 12 AWG minimum conductor size. Minimum insulation rating of 90 degrees C. Insulation Type: THHN/THWN-2.
- B. Phase color to be consistent at feeder terminations; A-B-C, top to bottom, left to right, front to back.
- C. Color Code Conductors as Follows:

PHASE	208 VOLT WYE	240 VOLT DELTA	480 VOLT
A	Black	Black	Brown
B	Red	Orange (High Leg)	Orange
C	Blue	Blue	Yellow
Neutral	White	White	Gray or White w/colored strip
Ground	Green	Green	Green
Isolated Ground	Green w/yellow trace	N/A	N/A

- D. MC Cable:
 - 1. Standard: High strength galvanized steel flexible armor. Full length minimum size No. 12 copper ground wire, copper dual rated THHN/THWN-2, full length tape marker phase/circuit identification on cable armor. Short circuit throat insulators, mechanical compression termination.
- E. AC Cable (Armored Cable): Not allowed.
- F. NMB Cable: Not allowed.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

2.4 CONNECTORS

- A. Split bolt connectors not allowed.
- B. Conductor Branch Circuits: Wire nuts with integral spring connectors for conductors 12 AWG through 8 AWG. Push-in type connectors where conductors are not required to be twisted together are not acceptable.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Install per manufacturer instructions and NEC.
- B. Field Quality Control:
 - 1. Test conductor insulation on feeders of 100 amp and greater for conformity with 1000 volt megohmmeter. Use Insulated Cable Engineers Association testing procedures. Minimum insulation resistance acceptable is 1 megohm for systems 600 volts and below. Notify Architect if insulation resistance is less than 1 megohm.
 - 2. Test Report: Prepare a typed tabular report indicating the testing instrument, the feeder tested, amperage rating of the feeder, insulation type, voltage, the approximate length of the feeder, conduit type, and the measured resistance of the megohmmeter test. Submit test reports with project closeout documents.
 - 3. Inspect and test in accordance with NETA Standard ATS, except Section 4.
 - 4. Perform inspections and tests listed in NETA Standard ATS, Section 7.3.2.

3.2 LUGS AND PADS

- A. Thoroughly clean surfaces to remove all dirt, oil, grease or paint.
- B. Use torque wrench to tighten per manufacturer's directions.

3.3 WIRES AND CABLES

- A. General:
 - 1. Do not install or handle thermoplastic insulated wire and cable in temperatures below -10 degrees C (14 degrees F). Do not handle thermoset insulated wire and cable in temperatures below -40 degrees C (-40 degrees F). All wire and cable must be acclimated to temperatures above freezing for no less than 24 hours prior to installation.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

2. Install conductors in raceways having adequate, code size cross-sectional area for wires indicated.
 3. Install conductors with care to avoid damage to insulation.
 4. Do not apply greater tension on conductors than recommended by manufacturer during installation.
 5. Use of pulling compounds is permitted. Clean residue from exposed conductors and raceway entrances after conductor installation. Do not use pulling compounds for installation of conductors connected to GFCI circuit breakers or GFCI receptacles.
 6. Conductor Size and Quantity:
 - a. Install no conductors smaller than 12 AWG unless otherwise shown.
 - b. Provide required conductors for a fully operable system.
 - c. Power Circuits: No. 12 AWG minimum, except as follows:
 - (1) No. 10 AWG for 15A, 120V circuits longer than 100 ft.
 - (2) No. 8 AWG for 15A, 120V circuits longer than 150 ft.
 - (3) No. 10 AWG for 20A, 120V circuits longer than 70 ft.
 - (4) No. 8 AWG for 20A, 120V circuits longer than 100 ft.
 - d. When exact run lengths are determined for all branch circuits, and prior to installation of the conductors, ensure that the maximum voltage drop, based on 80 percent of the circuit protective device, does not exceed 3 percent. Increase wire size from #12AWG, if necessary, to ensure that the 3 percent voltage drop is not exceeded.
 7. Provide dedicated neutrals (one neutral conductor for each phase conductor) in all 120V circuits.
- B. Conductors in Cabinets:
1. Cable and tree wires in panels and cabinets for power and control. Use plastic ties in panels and cabinets.
 2. Tie and bundle feeder conductors in wireways of panelboards.
 3. Hold conductors away from sharp metal edges.
- C. Homeruns:

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

1. Do not change intent of branch circuit homeruns without approval. Homeruns for 20A branch circuits may be combined to a maximum of six current carrying conductors including neutral conductors in homeruns. Apply derating factors as required per NEC. Increase conductor size as needed.
 2. MC cable homeruns are not allowed unless indicated on drawings.
- D. Exposed cable is not allowed.
- E. All cable must be run parallel or perpendicular to building lines and hidden from view when possible. Where installed in tray each power cable is to be identified with Lamacoid nametag engraved with identification of equipment being fed. Tag to be fastened to cable using tie-wraps. Provide nametag at each floor level.
- F. Do not install PVC jacketed cables in return air plenums, unless they are specially rated plenum cables.
- G. Use of MC Cable is limited to the following conditions. Installations that do not comply with the following conditions are to be removed and replaced with no additional expense to the Owner.
1. 15 and 20 amp branch wiring where following conditions apply:
 - a. Use MC cable for final flexible connections from junction or outlet boxes to recessed fixtures. Do not use MC cables to loop between fixtures, except where it is not practical to provide conduit connections between boxes or where existing inaccessible ceilings prevent installation of conduit runs. Each individual luminaire is to be serviced by an individual cable drop from the associated junction box in the ceiling space. Maximum length 6-feet of MC cable. Luminaire drops secured to, and supported by, the building structure with nylon tie wraps. The use of the ceiling suspension system for support of any type of cabling is not permitted.
 - b. MC cable may be routed in the void space above hard lid ceilings, and routed within wall cavities below glazing, provided NEC requirements are otherwise met, and a minimum one 0.75-inch conduit is routed from nearest accessible ceiling space to inaccessible location, terminating in a j-box with blank faceplate, for future circuits.

3.4 CONNECTORS

- A. Install to assure a solid and safe connection.
- B. Select hand twist connectors for wire size and install tightly on conductors.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

- C. Install compression connectors using methods and tools recommended by the manufacturer.
- D. Do not install stranded conductors under screw terminals unless compression lugs are installed.
- E. Do not connect wiring without UL listed connectors that are listed for the purposes.

END OF SECTION

This page intentionally left blank

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Connectors and Accessories
2. Grounding Conductor

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

B. In addition, provide:

1. Test reports of ground resistance for service and separately derived system grounds.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:

1. Comply with the requirements of ANSI/NFPA 70.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Connectors and Accessories:

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1. Burndy Hyground Compression System
 2. Erico/Cadweld
 3. Amp Ampact Grounding System
 4. Pipe Grounding Clamp:
 - a. Burndy GAR Series
 - b. O Z Gedney
 - c. Thomas & Betts
 - d. Or approved equivalent.
- B. Grounding Conductor
1. General Cable
 2. Okonite
 3. Southwire
 4. Or approved equivalent

2.2 CONNECTORS AND ACCESSORIES

- A. Grounding Connectors: Hydraulic compression tool applied connectors or exothermic welding process connectors or powder actuated compression tool applied connectors.
- B. Pipe Grounding Clamp: Mechanical ground connector with cable parallel or perpendicular to pipe.

2.3 GROUNDING CONDUCTOR

- A. Grounding Electrode Conductor: Soft-draw bare stranded copper for wire sizes larger than #10 AWG Bare. Solid copper for wire sizes #10 AWG and smaller.
- B. Equipment Grounding Conductor: Green insulated, insulation type to match that of associated feeder or branch circuit wiring, size as indicated on drawings.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Verify site conditions prior to beginning work.
- B. Bond Sections of service equipment enclosure to service ground bus.

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

- C. Separately Derived Systems: Ground each separately derived system per NEC Article 250.
- D. Corrosion inhibitors: Apply a corrosion inhibitor to contact surfaces when making grounding and bonding connections. Use corrosion inhibitor appropriate for protecting a connection between metals used.
- E. Grounding system resistance to ground not to exceed 5 ohms. Make necessary modifications or additions to grounding electrode system for compliance. Submit final tests to assure that this requirement is met.
- F. Resistance of grounding electrode system: measure using a four-terminal fall-of-potential method as defined in IEEE 81. Take ground resistance measurements before electrical distribution system is energized and in normally dry conditions, not less than 48 hours after last rainfall. Take resistance measurements of separate grounding electrode systems before systems are bonded together below grade. Combined resistance of separate systems may be used to meet required resistance, but specified number of electrodes must still be provided.
- G. Inspect and test in accordance with NETA Standard ATS, Except Section 4.
- H. Perform inspections and tests listed in NETA Standard AB, Section 7.13.

3.2 CONNECTORS AND ACCESSORIES INSTALLATION

- A. Install per manufacturer's instructions.

3.3 GROUNDING CONDUCTOR INSTALLATION

- A. Raceways:
 - 1. Ground metallic raceway systems. Bond to ground terminal with code size jumper except where code size or larger equipment grounding conductor is included with circuit, use grounding bushing with lay-in lug.
 - 2. Connect metal raceways, which terminate within an enclosure but without mechanical connection to enclosure, by grounding bushings and ground conductor to grounding bus.
 - 3. Where equipment supply conductors are in flexible metallic conduit, install stranded copper equipment grounding conductor from outlet box to equipment frame.
 - 4. Install equipment grounding conductor, code size minimum unless noted on drawings, in metallic and nonmetallic raceway systems.
- B. Feeders and Branch Circuits:

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1. Provide continuous green insulated copper equipment grounding conductors for feeders and branch circuits.
 2. Where installed in a continuous solid metallic raceway system and larger sizes are not detailed, provide insulated equipment grounding conductors for feeders and branch circuits sized in accordance with the latest adopted edition of NEC Article 250, Table 250-122.
- C. Bond boxes, cabinets, enclosures and panelboard equipment grounding conductors to enclosure with specified conductors and lugs. Install lugs only on thoroughly cleaned contact surfaces.
- D. Motors, Equipment and Appliances: Install code size equipment grounding conductor to (motor) equipment frame or manufacturer's designated ground terminal.
- E. Receptacles: Connect ground terminal of receptacle and associated outlet box to equipment grounding conductor. Self grounding nature of receptacle devices does not eliminate equipment grounding conductor bolted to outlet box.

END OF SECTION

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Anchors, Threaded Rod and Fasteners
2. Support Channel, Hangers and Supports
3. Rooftop Conduit Supports

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals not required for this Section.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
1. Manufacturers regularly engaged in the manufacture of bolted metal framing support systems, whose products have been in satisfactory use in similar service for not less than 10 years.
 2. Support systems to be supplied by a single manufacturer.
 3. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, equipment hangers/supports, and seismic restraint by a qualified Structural Professional Engineer.
 - a. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.7 PERFORMANCE REQUIREMENTS

- A. General: Provide conduit and equipment hangers and supports in accordance with the following:
 - 1. When supports, anchorages, and seismic restraints for equipment and supports, anchorages and seismic restraints for conduit, cable tray and equipment are not shown on the Drawings, the Contractor is responsible for their design.
 - 2. Connections to structural framing shall not introduce twisting, torsion, or lateral bending in the framing members. Provide supplementary steel as required.
- B. Engineered Support Systems: The following support systems to be designed, detailed, and bear the seal of a professional engineer registered in the State of Oregon.
 - 1. Support frames such as conduit racks or stanchions for conduit and equipment which provide support from below.
 - 2. Equipment and piping support frame anchorage to supporting slab or structure.
- C. Provide channel support systems, for conduits to support multiple conduits capable of supporting combined weight of support systems and system contents.
- D. Provide heavy-duty steel trapezes for piping to support multiple conduit capable of supporting combined weight of supported systems and system contents.
- E. Provide seismic restraint hangers and supports for conduit and equipment.
- F. Obtain approval from AHJ for seismic restraint hanger and support system to be installed for piping and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Anchors, Threaded Rod and Fasteners:
 - 1. Anchor It
 - 2. Epcon System
 - 3. Hilti-Hit System
 - 4. Power Fast System

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

5. Or approved equivalent.
- B. Support Channel, Hangers and Supports:
1. B-Line
 2. Kindorf
 3. Superstrut
 4. Unistrut
 5. Or approved equivalent.
- C. Rooftop Conduit Supports:
1. Cooper B-Line Dura-Block Rooftop Support Base
 2. Or approved equivalent.

2.2 ANCHORS, THREADED ROD AND FASTENERS

- A. Anchors, Threaded Rod and Fasteners - General: Corrosion-resistant materials of size and type adequate to carry the loads of equipment and conduit, including weight of wire in conduit.
- B. Concrete Inserts: Cast in concrete for support fasteners for loads up to 800 lbs.
- C. Anchors and Fasteners:
1. Do not use powder-actuated anchors.
 2. Concrete Structural Elements: Use precast inserts.
 3. Steel Structural Elements: Use beam clamps.
 4. Concrete Surfaces: Use self-drilling anchors.
 5. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts.
 6. Solid Masonry Walls: Use expansion anchors.
 7. Sheet Metal: Use sheet metal screws.
 8. Wood Elements: Use wood screws.
- D. Fasteners: Provide fasteners of types as required for assembly and installation of fabricated items; surface-applied fasteners are specified elsewhere.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

- E. Bolts: Low carbon steel externally and internally threaded fasteners conforming with requirements of ASTM A307; include necessary nuts and plain hardened washers. For structural steel elements supporting mechanical material or equipment from building structural members or connection thereto, use fasteners conforming to ASTM A325.
- F. Miscellaneous Materials: Provide incidental accessory materials, tools, methods, and equipment required for fabrication.

2.3 SUPPORT CHANNEL, HANGERS AND SUPPORTS

- A. Hangers and Supports - General: Corrosion-resistant materials of size and type adequate to carry the loads of equipment and conduit, including weight of wire in conduit.
 - 1. Channel Material: Carbon steel.
 - 2. Coating: Hot dip galvanized.
- B. Pipe Straps: Two-hole galvanized or malleable iron.
- C. Luminaire Chain: 90 lb. test with steel hooks.
- D. Miscellaneous Metal: Provide miscellaneous metal items specified hereunder, including materials, fabrication, fastenings and accessories required for finished installation, where indicated on Drawings or otherwise not shown on drawings that are necessary for completion of the project. The Contractor is responsible for their design.
 - 1. Fabricate miscellaneous units to size shapes and profiles indicated or, if not indicated, of required dimensions to receive adjacent other work to be retained by framing. Except as otherwise shown, fabricate from structural steel shapes and plates and steel bars, of welded construction using mitered joints for field connection. Cut, drill and tap units to receive hardware and similar items.
- E. Structural Shapes: Where miscellaneous metal items are needed to be fabricated from structural steel shapes and plates, provide members constructed of steel conforming with requirements of ASTM A36 or approved equivalent.
- F. Steel Pipe: Provide seamless steel pipe conforming to requirements of ASTM A53, Type S, Grade A, or Grade B. Weight and size required as specified.
- G. Miscellaneous Materials: Provide incidental accessory materials, tools, methods, and equipment required for fabrication.

2.4 ROOFTOP CONDUIT SUPPORTS

- A. Curb base made of 100 percent recycled rubber and polyurethane prepolymer with a uniform load
- B. Capacity of 500 pounds per linear foot of support.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

- C. UV resistant.
- D. Steel Frame: Steel, 14 gauge strut galvanized per ASTM A653 or 12 gauge strut galvanized per ASTM A653 for bridge series.
- E. Continuous block channel supports with 1-inch gaps to allow water flow, bridge channel supports, extendable height channel supports and elevated single conduit supports.
- F. Attaching Hardware: Zinc-plated threaded rod, nuts and attaching hardware per ASTM B633 fastened directly into rubber material with weather resistant Type 12 lag screws.
- G. Provide load distribution plates when required for heavy loads.
- H. Finish: Black with safety yellow striping.
- I. Provide hot dipped galvanized components for items exposed to weather.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Fabrication - Miscellaneous Metals
 - 1. General: Verify dimensions prior to fabrication. Form metal items to accurate sizes and configurations as indicated on Drawings and otherwise required for proper installation; make with lines straight and angles sharp, clean and true; drill, countersink, tap, and otherwise prepare items for connections with work of other trades, as required. Fabricate to detail of structural shapes, plates and bars; weld joints where practicable; provide bolts and other connection devices required. Include anchorages; clip angles, sleeves, anchor plates, and similar devices. Hot dipped galvanize after fabrication items installed in exterior locations. Set accurately in position as required and anchor securely to building construction. Construct items with joints formed for strength and rigidity, accurately machining for proper fit; where exposed to weather, form to exclude water.
 - 2. Finishes:
 - a. Ferrous Metal: After fabrication, but before erection, clean surfaces by mechanical or chemical methods to remove rust, scale, oil, corrosion, or other substances detrimental to bonding of subsequently applied protective coatings. For metal items exposed to weather or moisture, galvanize in manner to obtain G90 zinc coating in accordance with ASTM A123. Provide other non-galvanized ferrous metal with one coat of approved rust-resisting paint primer, in manner to obtain not less than 1.0 mil dry film thickness. Touch-up damaged areas in primer with same material, before installation. Apply zinc coatings and paint primers

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

uniformly and smoothly; leave ready for finish painting as specified elsewhere.

- b. Metal in contact with Concrete, Masonry and Other Dissimilar Materials: Where metal items are to be erected in contact with dissimilar materials, provide contact surfaces with coating of an approved zinc-chromate primer in manner to obtain not less than 1.0 mil dry film thickness, in addition to other coatings specified in these specifications.
- c. For Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A780.

3.2 ANCHORS, THREADED ROD AND FASTENERS INSTALLATION

- A. Safety factor of 4 required for every fastening device or support for equipment installed. Supports to withstand four times the weight of equipment it supports.
- B. Do not use other trade's fastening devices as supporting means for luminaires, equipment or materials.
- C. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.
- D. Do not use supports or fastening devices to support other than one particular item.
- E. Securely suspend junction boxes, pull boxes or other conduit terminating housings located above suspended ceiling from floor above or roof structure to prevent sagging and swaying.
- F. Provide seismic bracing per IBC requirements.
- G. Install surface-mounted cabinets and panelboards with minimum of four anchors.
- H. Use spring lock washers under fastener nuts for strut.
- I. Cutting and Drilling
 - 1. Do not drill or cut structural members without prior permission from Architect.

3.3 SUPPORT CHANNEL, HANGERS AND SUPPORTS INSTALLATION

- A. Install hangers and supports as required to adequately and securely support electrical system components, in a neat and workmanlike manner, as specified in NECA 1.
- B. Safety factor of 4 required for every fastening device or support for equipment installed. Supports to withstand four times the weight of equipment it supports.
- C. Verify mounting height of luminaires prior to installation when heights are not detailed.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

- D. Install vertical support members for equipment and luminaires, straight and parallel to building walls.
- E. Install horizontal support members straight and parallel to ceilings or finished floor unless otherwise noted.
- F. Provide independent supports to structural member for luminaires, materials, or equipment installed in or on ceiling, walls or in void spaces or over suspended ceilings.
- G. Do not use other trade's fastening devices as supporting means for luminaires, equipment or materials.
- H. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.
- I. Do not use supports or fastening devices to support other than one particular item.
- J. Support conduits within 18-inches of outlets, boxes, panels, cabinets and deflections unless more stringently required by NEC.
- K. Maximum distance between supports not to exceed 8 foot spacing unless otherwise required by NEC.
- L. Support flexible conduits and metal clad cable within 12-inches of outlets, boxes, panels, cabinets and deflections unless otherwise required by NEC.
- M. Maximum distance between supports for flexible conduits and metal clad cable not to exceed 48-inches spacing unless otherwise required by NEC.
- N. Maximum distance between supports for rigid PVC conduits unless otherwise required by NEC is as follows:
 - 1. 1/2-inch or 3/4-inch and 1-inch conduit, 3-feet apart.
 - 2. 1-1/4-inch or 1-1/2-inch and 2-inch conduit, 4-feet apart.
 - 3. 2-1/2-inch and 3-inch conduit, 5-feet apart.
 - 4. 4-inch and 5-inch conduit, 6-feet apart.
 - 5. 6-inch conduit, 7-feet apart.
- O. Maximum distance between supports for auxiliary gutters and wireways unless otherwise required by NEC is as follows:
 - 1. Sheet metal auxiliary gutters and wireways - 4-feet apart horizontally and 10-feet vertically.
 - 2. Non-metallic auxiliary gutters and wireways - 30-inches apart horizontally and 3-feet vertically.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS AND EQUIPMENT

- P. Install strut hangers as instructed by strut manufacturer. Suspend strut hangers as instructed by strut manufacturer for the load, with a maximum spacing of 8-feet on center and within 2-feet of outlet box, cabinet, junction box or other channel raceway termination unless otherwise required by NEC.
- Q. Coordinate routing of conduit racks with materials and equipment installed by other trades. Where conduit racks are exposed to view, coordinate location and installation with Architect for optimal appearance.
- R. Securely suspend junction boxes, pull boxes or other conduit terminating housings located above suspended ceiling from floor above or roof structure to prevent sagging and swaying.
- S. Provide seismic bracing per IBC requirements.
- T. Where service disconnects are mounted on building exterior, physically attach service disconnect to the building or structure served.
- U. Install surface-mounted cabinets and panelboards with minimum of four anchors.
- V. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.
- W. Wet and Damp Locations:
 - 1. In wet and damp locations use steel channel supports to stand cabinets and panelboards 1-inch off wall.

3.4 ROOFTOP CONDUIT SUPPORTS INSTALLATION

- A. Consult roofing manufacturer for roof membrane compression capacities. If necessary, provide a compatible sheet of roofing material (rubber pad) under rooftop support to disperse concentrated loads and add further membrane protection.
- B. Do not use supports that will void roof warranty.
- C. Install supports per manufacturer's instructions and recommendations.
- D. Use properly sized clamps to suit conduit sizes.
- E. Install supports for rooftop raceways to raise raceways a minimum of 7/8-inches above the roof structure unless otherwise noted.

END OF SECTION

RACEWAYS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Rigid Metal Conduit (RMC)
 - 2. Electrical Metallic Tubing (EMT)
 - 3. Flexible Metal Conduit (FMC)
 - 4. Liquidtight Flexible Metal Conduit (LFMC)
 - 5. Conduit Fittings
- B. Provide a complete system of conduit and fittings, with associated couplings, connectors, and fittings, as shown on Drawings and described in these Specifications.

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.
- B. In addition, reference the following:
 - 1. Section 26 05 29, Hangers and Supports for Electrical Systems and Equipment
 - 2. Section 26 05 34, Boxes

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

RACEWAYS

1.7 DEFINITIONS

- A. Raceway system is defined as consisting of conduit, tubing, duct, and fittings including but not limited to connectors, couplings, offsets, elbows, bushings, expansion/deflection fittings, and other components and accessories. Complete electrical raceway installation before starting the installation of conductors and cables.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Rigid Metal Conduit (RMC):
1. Allied Tube & Conduit
 2. Beck Manufacturing Inc.
 3. Picoma
 4. Wheatland Tube Company
 5. Or approved equivalent.
- B. Electrical Metallic Tubing (EMT):
1. Allied Tube & Conduit
 2. Beck Manufacturing WL
 3. Picoma
 4. Wheatland Tube Company
 5. Or approved equivalent.
- C. Flexible Metal Conduit (FMC):
1. AFC Cable Systems Inc.
 2. Electri-Flex Company
 3. International Metal Hose
 4. Or approved equivalent.
- D. Liquidtight Flexible Metal Conduit (LFMC):
1. AFC Cable Systems Inc.
 2. Electri-Flex Company

RACEWAYS

3. International Metal Hose
 4. Or approved equivalent.
- E. Conduit Fittings:
1. Bushings:
 - a. Insulated Type for Threaded Raceway Without Factory Installed Plastic Throat Conductor Protection:
 - (1) Thomas & Betts 1222 Series
 - (2) O-Z Gedney B Series
 - (3) Or approved Equivalent.
 2. Raceway Connectors and Couplings:
 - a. Thomas & Betts Series
 - b. O-Z Gedney Series
 - c. Or approved Equivalent.
 3. Expansion/Deflection Fittings:
 - a. EMT: O-Z Gedney Type TX
 - b. RMC: O-Z Gedney Type AX, DX and AXDX, Crouse & Hinds XD
 - c. PVC: O-Z Gedney Type DX with PVC adapters, Carlon E945 Series, Kraloy OPEJ Series
 - d. Or approved equivalent.
- 2.2 RIGID METAL CONDUIT (RMC)
- A. UL 6, ANSI C80.1. Hot dipped galvanized steel conduit after thread cutting.
 1. Fittings: NEMA FB2.10.
- 2.3 ELECTRICAL METALLIC TUBING (EMT)
- A. Description: UL 797, ANSI C80.3; steel galvanized tubing.
 - B. Fittings: NEMA FB 1; steel, compression type.

RACEWAYS

2.4 FLEXIBLE METAL CONDUIT (FMC)

- A. Description: UL 1, interlocked steel construction.
- B. Fittings: NEMA FB 2.20.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Description: UL 360, inner core made from spiral wound strip of heavy gauge, hot dipped galvanized low carbon steel. 3/4-inch through 1-1/4-inch trade sizes to have a square lock core and contain an integral bonding strip of copper. 1-1/2-inch and larger to have fully interlocked core. Jacket material to be moisture, oil and sunlight resistant flexible PVC.
- B. Fittings: NEMA FB 2.20.

2.6 CONDUIT FITTINGS

- A. Bushings:
 - 1. Insulated type for threaded raceway connectors without factory-installed plastic throat conductor protection.
 - 2. Insulated grounding type for threaded raceway connectors.
- B. Raceway Connectors and Couplings:
 - 1. Steel connectors, couplings, and conduit bodies, hot-dip galvanized.
 - 2. Connector locknuts to be steel, with threads meeting ASTM tolerances. Locknuts to be hot-dip galvanized.
 - 3. Connector throats (EMT, flexible conduit, metal clad cable and cordset connectors) to have factory installed plastic inserts permanently installed. For normal cable or conductor exiting angles from raceway, the cable jacket or conductor insulation to bear only on plastic throat insert.
 - 4. Steel gland, Tomic or Breagle connectors and couplings are recognized for this Contract as having acceptable raceway to fitting electrical conductance.
 - 5. Set screw connectors and couplings, without integral compression glands, are recognized for this Contract as not having acceptable raceway to fitting electrical conductance. A ground conductor sized per this Specification must be included and bonded within raceway assembly utilizing this type connector or coupling.
- C. Provide expansion/deflection fittings for EMT.

RACEWAYS

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Finished Surfaces: Schedule raceway installation to avoid conflict with installed wall and ceiling surfaces. If unavoidable, coordinate work and repairs with Architect.
- B. Conduit Size:
 - 1. Minimum Size: 3/4-inch for power and control, unless otherwise noted. 3/4-inch for communication/data, unless otherwise noted. 3/4-inch for signal systems, unless otherwise noted.
- C. Underground Installations:
 - 1. More than 5-feet from Foundation Wall: Use PVC.
 - 2. Within 5-feet from Foundation Wall: Use PVC coated RMC.
 - 3. In or Under Slab on Grade: Use PVC.
 - 4. Minimum Size: 1-inch.
- D. In Slab Above Grade:
 - 1. Use PVC.
 - 2. Maximum Size Conduit in Slab: Contact Structural Engineer for maximum outside diameter of conduit.
- E. Provide two pull strings/tapes in empty conduits. Types:
 - 1. Feeders: Polyester measure/pulling tape, Greenlee 4436 or approved.
 - 2. Branch Circuits and Low Voltage: Greenlee Poly Line 431 or approved.
 - 3. If fish tape is used for pulling line or low voltage wiring, fiberglass type to be used. Metal fish tapes will not be allowed.
 - 4. Secure pull string/tape at each end.
 - 5. Provide caps on ends of empty conduit to be used in future.
 - 6. Label both ends of empty conduits with location of opposite end.
- F. Elbows: Use fiberglass or PVC coated RMC for underground installations.
- G. Elbow for Low Energy Signal Systems: Use long radius factory ells where linking sections of raceway for installation of signal cable.

RACEWAYS

- H. Verify that field measurements are as shown on Drawings.
- I. Plan locations of conduit runs in advance of the installation and coordinate with ductwork, plumbing, ceiling and wall construction in the same areas.
- J. Locate penetrations and holes in advance where they are proposed in the structural sections such as footings, beams, and walls. Penetrations are acceptable only when the following occurs:
 - 1. Where shown on the Structural Drawings.
 - 2. As approved by the Structural Engineer prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
- K. Verify routing and termination locations of conduit prior to rough-in.
- L. Conduit routing is shown on drawings in approximate locations unless dimensioned. Route as required to complete wiring system.
- M. Install raceways securely, in neat and workmanlike manner, as specified in NECA 1, Standard Practices for Good Workmanship in Electrical Construction.
- N. Install steel conduit as specified in NECA 101, Standard for Installing Steel Conduits.
- O. Install nonmetallic conduit in accordance with manufacturer's instructions.
- P. Inserts, anchors and sleeves.
 - 1. Coordinate location of inserts and anchor bolts for electrical systems prior to concrete pour.
 - 2. Coordinate location of sleeves with consideration for other building systems prior to concrete pour.
- Q. Conduit Supports:
 - 1. Arrange supports to prevent misalignment during wiring installation.
 - 2. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.
 - 3. Group related conduits; support using conduit rack. Construct rack using steel channel. Provide space on each for 25 percent additional conduits.
 - 4. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.
 - 5. Do not attach conduit to ceiling support wires.

RACEWAYS

- R. Flexible metal conduit length not-to-exceed 6-feet, 3-feet in concealed walls. Provide sufficient slack to reduce the effect of vibration.
- S. Install conduit seals at boundaries where ambient temperatures differ by 10 degrees F or more as shown on the drawings. Install seals on warm side of partition.
- T. Seal raceways stubbing up into electrical equipment. Plug raceways with conductors with duct-seal. Cap spare raceways and plug PVC raceway products with plastic plugs as made by Underground Products, or equal, shaped to fit snugly into the stubup.
- U. Seal raceways penetrating an exterior building wall to prevent moisture and vermin from entering into the electrical equipment.
- V. Use suitable caps on spare and empty conduits to protect installed conduit against entrance of dirt and moisture.
- W. Keep 277/480 volt wiring independent of 120/208 volt wiring. Keep power wiring independent of communication system wiring.
- X. Keep emergency system wiring independent of other wiring systems per NEC 700.
- Y. Arrange conduit to maintain headroom and present neat appearance.
- Z. Do not install conduits on surface of building exterior, along vapor barrier, across roof, on top of parapet walls, or across floors, unless otherwise noted on drawings.
- AA. Exposed conduits are permitted only in following areas:
 - 1. Mechanical rooms, electrical rooms or spaces where walls, ceilings and floors will not be covered with finished material.
 - 2. Existing walls that are concrete or block construction.
 - 3. Where specifically noted on Drawings.
 - 4. Route exposed conduit parallel and perpendicular to walls, tight to finished surfaces and neatly offset into boxes.
- BB. Do not install conduits or other electrical equipment in obvious passages, doorways, scuttles or crawl spaces which would impede or block area passage's intended usage.
- CC. Install continuous conduit and raceways for electrical power wiring and signal systems wiring.
- DD. Route conduit installed above accessible ceilings parallel and perpendicular to walls.
- EE. Maintain adequate clearance between conduit and piping.

RACEWAYS

- FF. Keep conduits a minimum of 12-inches away from steam or hot water radiant heating lines (at or above 104 degrees F) or 3-inches away from waste or water lines.
- GG. Cut conduit square using saw or pipecutter; deburr cut ends.
- HH. Bring conduit to shoulder of fittings; fasten securely.
- II. Use conduit hubs to fasten conduit to cast boxes in damp and wet locations.
- JJ. Install no more than the equivalent of three 90 degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams.
- KK. Use hydraulic one shot bender to fabricate elbows for bends in metal conduit larger than 2-inch size.
- LL. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.
- MM. Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic, control, and expansion joints.
- NN. Conduit Terminations for Signal Systems: Provide a plastic bushing on the end of conduit used for signal system wiring.
- OO. Feeders: Do not combine or change feeder runs.
- PP. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Division 07, Thermal and Moisture Protection.
- QQ. Route conduit through roof openings for piping and ductwork wherever possible. Where separate roofing penetration is required, coordinate location and installation method with roofing installation and installer.

3.2 RIGID METAL CONDUIT (RMC) INSTALLATION

- A. Outdoor Locations Above Grade: RMC.
- B. Damp Locations: RMC.
- C. In areas exposed to mechanical damage: RMC.
- D. For security conduits installed exposed and subject to tampering: RMC.

3.3 ELECTRICAL METALLIC TUBING (EMT) INSTALLATION

- A. Dry Locations:
 - 1. Concealed: EMT.

RACEWAYS

2. Exposed: EMT.

B. Dry, Protected: EMT.

3.4 FLEXIBLE METAL CONDUIT (FMC) INSTALLATION

A. Dry Locations: Motors, recessed luminaires and equipment connections subject to movement or vibration, use flexible metallic conduit.

B. Install 12-inch minimum slack loop on flexible metallic conduit.

3.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC) INSTALLATION

A. Use PVC coated liquidtight flexible metallic conduit for motors and equipment connections subject to movement or vibration and subjected to any of following conditions: Exterior location, moist or humid atmosphere, corrosive environments, water spray, oil, or grease.

B. Install 12-inch minimum slack loop on liquidtight flexible metallic conduit.

3.6 CONDUIT FITTINGS INSTALLATION

A. Conduit Joints: Assemble conduits continuous and secure to boxes, panels, luminaires and equipment with fittings to maintain continuity. Provide watertight joints where embedded in concrete, below grade or in damp locations. Seal metal conduit with metal thread primer. Rigid conduit connections to be threaded, clean and tight (metal to metal). Threadless connections are not permitted for RMC.

B. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

C. Use set screw type fittings only in dry locations. When set screw fittings are utilized provide insulated continuous equipment ground conductor in conduit, from overcurrent protection device to outlet.

D. Use compression fittings in dry locations, damp and rain-exposed locations. Maximum size permitted in damp locations and locations exposed to rain is 2-inches in diameter.

E. Use threaded type fittings in wet locations, hazardous locations, and damp or rain-exposed locations where conduit size is greater than 2-inches.

F. Use PVC coated, threaded type fittings in corrosive environments.

G. Use insulated type bushings with ground provision at switchboards, panelboards, safety disconnect switches, junction boxes that have feeders 60 amperes and greater.

H. Condulets and Conduit Bodies:

RACEWAYS

1. Do not use condulets and conduit bodies in conduits for signal wiring, in feeders 100 amp and larger, or for conductor splicing.
- I. Sleeves and Chases - Floor, Ceiling and Wall Penetrations: Provide necessary rigid conduit sleeves, openings and chases where conduits or cables are required to pass through floors, ceilings or walls.
- J. Expansion Joints:
1. Provide conduits crossing expansion joints where cast in concrete with expansion-deflection fittings, installed per manufacturer's recommendations.
 2. Secure conduits 3-inches and larger to building structure on opposite sides of a building expansion joint with an expansion-deflection fitting across joint installed per manufacturer's recommendations.
 3. Provide conduits less than 3-inches where not cast in concrete with junction boxes securely fastened on both sides of expansion joint, connected together with 15-inches of slack (minimum of 15-inches longer than straight line length) flexible conduit and copper green ground bonding jumper. In lieu of this flexible conduit, an expansion-deflection fitting, as indicated for conduits 3-inch and larger may be installed.
 4. Verify expansion/deflection requirements with Structural Engineer prior to installation.
- K. Seismic Joints:
1. No conduits cast in concrete allowed to cross seismic joint.
 2. Provide conduits with junction boxes securely fastened on both sides of seismic joint, connected together with 15-inches of slack (minimum of 15-inches longer than straight line length) flexible conduit and copper green ground bonding jumper. Prior to installation, verify with Architect that 15-inches is adequate for designed movement, and if not, increase this length as required.
 3. Provide conduits less than 3-inches where not cast in concrete with junction boxes securely fastened on both sides of expansion joint, connected together with 15-inches of slack (minimum of 15-inches longer than straight line length) flexible conduit and copper green ground bonding jumper. In lieu of this flexible conduit, an expansion-deflection fitting, as indicated for conduits 3-inches and larger may be installed.
- L. Provide rigid conduit coupling flush with surface of slab or wall for conduit stubbed in concrete slab or wall to serve electrical equipment or an outlet under table or to supply shop tool, etc. Provide plug where conduit is to be used in future.

RACEWAYS

END OF SECTION

This page intentionally left blank

BOXES

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Outlet Boxes
 - 2. Pull and Junction Boxes
 - 3. Box Extension Adapter
 - 4. Weatherproof Outlet Boxes
- B. Provide electrical boxes and fittings for a complete installation. Include but not limited to outlet boxes, junction boxes, pull boxes, bushings, locknuts and other necessary components.

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.
- B. In addition, reference the following:
 - 1. Section 26 05 33, Raceways
 - 2. Section 26 05 53, Identification for Electrical Systems

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

BOXES

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Outlet Boxes:

1. Hubbell
2. Thomas & Betts
3. Eaton/Crouse-Hinds
4. Or approved equivalent.

B. Pull and Junction Boxes:

1. Eaton/Crouse-Hinds
2. Hoffman
3. Or approved equivalent.

C. Box Extension Adapter:

1. Hubbell
2. Thomas & Betts
3. Eaton/Crouse-Hinds
4. Or approved equivalent.

D. Weatherproof Outlet Boxes:

1. Legrand (Pass & Seymour)
2. Hubbell
3. Thomas & Betts
4. Eaton/Crouse-Hinds
5. Intermatic
6. Or approved equivalent.

2.2 OUTLET BOXES

- A. Luminaire Outlet: 4-inch octagonal box, 1-1/2-inches deep with 3/8-inch luminaire stud if required. Provide raised covers on bracket outlets and on ceiling outlets.

BOXES

- B. Device Outlet: Installation of one or two devices at common location, minimum 4-inches square, minimum 1-1/2-inches deep for non-USB type devices. Installation of one or two devices at common locations, minimum 4-inches square, minimum 2-inches deep for USB type devices. Single- or two-gang flush device raised covers.
- C. Telecom Outlet: Provide 4-inches square, minimum 2-1/8-inch deep box with two-gang plaster ring.
- D. Multiple Devices: Three or more devices at common location. Install one-piece gang boxes with one-piece device cover. Install one device per gang.
- E. Masonry Boxes: Outlets in concrete.
- F. Construction: For interior locations, provide galvanized steel outlet wiring boxes, of the type, shape and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices. All surface mounted outlet boxes are to be drawn. Welded boxes are not acceptable.
- G. Accessories: Provide outlet box accessories for each installation, including mounting brackets, wallboard hangers, extension rings, luminaire studs, cable clamps and metal straps for supporting outlet boxes, compatible with outlet boxes being used and meeting requirements of individual wiring situations.
- H. Noise Control: Provide acoustic putty pad to back side of each outlet box installed in acoustic rated walls.

2.3 PULL AND JUNCTION BOXES

- A. Construction: Provide ANSI 61 gray polyester powder painted sheet steel junction and pull boxes, with screw-on covers; of type shape and size, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws and washers.
- B. Location:
 - 1. Provide junction boxes above accessible ceilings for drops into walls for receptacle outlets from overhead.
 - 2. Provide junction boxes and pull boxes to facilitate installation of conductors and limiting accumulated angular sum of bends between boxes, cabinets and appliances to 270 degrees.
- C. In-Ground Cast Metal Box: NEMA 250, Type 6, outside flanged, recessed cover box for flush mounting:
 - 1. Construction: Galvanized cast iron.

BOXES

2. Cover: Smooth cover with neoprene gasket and stainless steel cover screws.
 3. Cover Legend: ELECTRIC.
- D. Fiberglass Handholes: Die molded glass fiber hand holes:
1. Cable Entrance: Pre-cut 6- x 6-inch cable entrance at center bottom of each side.
 2. Cover: Fiberglass weatherproof cover with nonskid finish.
 3. Cover Legend: ELECTRIC.
- 2.4 BOX EXTENSION ADAPTER
- A. Construction: Diecast aluminum.
 - B. Location: Install over flush wall outlet boxes to permit flexible raceway extension from flush outlet to fixed or movable equipment.
- 2.5 WEATHERPROOF OUTLET BOXES
- A. Construction: Provide corrosion-resistant cast metal weatherproof outlet wiring boxes, of the type, shape and size, including depth of box, with threaded conduit ends, cast metal faceplate with spring-hinged waterproof cap suitably configured for each application, including faceplate, gasket, blank plugs and corrosion proof fasteners. Weatherproof boxes to be constructed to have smooth sides, gray finish.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate locations of floor boxes and wall mounted wiring device boxes with architectural and structural floor plans prior to rough-in.
- B. Install boxes securely, in a neat and workmanlike manner, as specified in NECA 1, Standard Practice of Good Workmanship in Electrical Construction.
- C. Secure boxes rigidly to substrate upon which they are being mounted, or solidly embed boxes in concrete or masonry.
- D. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and as required by NEC. Locate boxes and conduit bodies so as to ensure accessibility of electrical wiring.
- E. Set wall mounted boxes at elevations to accommodate mounting heights shown on Architectural Elevations.
- F. Electrical boxes are shown on drawings in approximate locations unless dimensioned.

BOXES

1. Adjust box locations up to 10-feet if required to accommodate intended purpose.
- G. Install boxes to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Division 07, Thermal and Moisture Protection.
- H. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.
- I. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
- J. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12-inches of box.
- K. Box Color Coding and Marking: Reference Section 26 05 53, Identification for Electrical Systems.
- L. Adjust boxes to be parallel with building lines. Boxes not plumb to building lines are not acceptable.
- M. Install knockout closures in unused box openings.
- N. Clean interior of boxes to remove dust, debris, and other material.
- O. Clean exposed surfaces and restore finish.

3.2 OUTLET BOXES INSTALLATION

- A. Mount outlet boxes, unless otherwise required by ADA, or noted on drawings, following distances above finished floor:
 1. Control Switches:
 - a. 48-inches to the top of outlet box.
 - b. 4-inches above top of backsplash at countertops/workstations, not-to-exceed 44-inches above finished floor to the top of outlet box per ADA requirements.
 2. Receptacles: 15-inches to the bottom of outlet box.
 3. Telecom Outlets: 15-inches to the bottom of outlet box.
 4. Other Outlets: As indicated in other sections of specifications or as detailed on drawings.
- B. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6-inches from ceiling access panel or from removable recessed luminaire.
- C. Flush Outlets in Insulated Spaces: Maintain integrity of insulation and vapor barrier.

BOXES

- D. Coordinate electrical device locations and elevations (switches and receptacles) with architectural drawings to prevent mounting devices in mirrors, back splashes, and behind cabinets.
- E. Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.
- F. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices. Adjacent boxes not aligned vertically to be adjusted at no additional cost to Owner.
- G. Use flush mounting outlet box in finished areas.
- H. Do not install flush mounting box back-to-back in walls; provide minimum 6-inches separation. Provide minimum 24-inches in acoustic rated walls.
- I. In acoustical walls, apply acoustic putty pad on outlet box prior to installation of acoustical blanket.
- J. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
- K. Use stamped steel bridges to fasten flush mounting outlet box between studs.
- L. Use adjustable steel channel fasteners for hung ceiling outlet box.
- M. Use gang box where more than one device is mounted together. Do not use sectional box.
- N. Use gang box with plaster ring for single device outlets.
- O. Adjust flush-mounting outlets to make front flush with finished wall material.

3.3 PULL AND JUNCTION BOXES INSTALLATION

- A. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
- B. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6-inches from ceiling access panel or from removable recessed luminaire.
- C. Do not fasten boxes to ceiling support wires.
- D. Large Pull Boxes: Use hinged enclosure in interior dry locations, surface-mounted cast metal box in other locations.

3.4 BOX EXTENSION ADAPTER INSTALLATION

- A. Match material to box.
- B. Install gaskets at exterior and wet locations.

BOXES

3.5 WEATHERPROOF OUTLET BOXES INSTALLATION

- A. Use cast outlet box in exterior locations exposed to weather and wet locations.
- B. Install gaskets.

END OF SECTION

This page intentionally left blank

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Equipment Nameplates
 - 2. Device Labels
 - 3. Wire Markers

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals not required for this Section.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
 - 1. Manufacturer's Qualifications: Firms regularly engaged in manufacture of identification devices of types and sizes required.
 - 2. Manufacturer's standard products of categories and types required for each application as referenced in other Division 26, Electrical Sections. Where more than a single type is specified for application, provide single selection for each product category.
 - 3. Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices unless otherwise indicated.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Equipment Nameplates:
 - 1. B & I Nameplates
 - 2. Intellicum
 - 3. JBR Associates
 - 4. Or approved equivalent.
- B. Device Labels:
 - 1. Kroy
 - 2. Brady
 - 3. Or approved equivalent.
- C. Wire Markers:
 - 1. Brady
 - 2. Panduit
 - 3. Sumitomo
 - 4. Or approved equivalent.

2.2 EQUIPMENT NAMEPLATES

- A. Engraved phenolic plastic, laminate, minimum 1/16-inch thick in the size indicated, with beveled edge border matching letter color. Federal specification LP-387A. All upper case letters in engraver standard letter style of the size and wording indicated. Provide with 2-mil adhesive backing. Embossed tape style labels are not acceptable.
- B. Color:
 - 1. Normal (Utility): White letters on black background.
 - 2. Life Safety/Critical (Emergency Systems): Black letters on orange background.
 - 3. Equipment Branch (Legally Required Standby Systems): Black letters on yellow background.
- C. Letter Size:

IDENTIFICATION FOR ELECTRICAL SYSTEMS

1. Use 1/2-inch letters minimum for identifying major equipment and loads, including switchgear, switchboards, distribution panels, generators, automatic transfer switches, UPS, etc.
 2. Use 1/4-inch or 1/2-inch letters minimum for identifying panels, breakers, transformers, VFDs, disconnects, etc.
 3. Use 3/16-inch minimum for identifying source, voltage, current, phase, wire configurations, and short circuit current rating (SCCR).
- D. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
- E. The Architect, Engineer, Commissioning Agent and Owner reserve the right to make modifications to the nameplates as necessary.
- F. Locations:
1. Switchgear, switchboards, sub-distribution switchboards, distribution panels, branch panels, automatic transfer switches, UPS.
 2. Main breakers and distribution breakers in switchgear, switchboards, and distribution panels.
 3. Equipment including, but not limited to, motor controllers, disconnects, and VFDs.
 4. Low-voltage equipment enclosures including, but not limited to, fire alarm panels, access control panels, and lighting control panels.
 5. Distribution transformers.

2.3 DEVICE LABELS

- A. Extra strength, laminated adhesive tape with 3/16-inch black letters on clear background. Embossed tape/punch tape style labels are not acceptable.
- B. Receptacles: Indicate source panel and source circuits (e.g. xxx-xx).
- C. Wall Switches/Control Device Stations:
1. Where controls are provided for remote lighting or power outlets, or where controls in same location serve different purposes or areas, such as corridor and outside, provide device label indicating function of each control device.
 2. Label the function of control devices where two or more are mounted in same location and control function may be unclear.

IDENTIFICATION FOR ELECTRICAL SYSTEMS

3. Wall switches with engraved buttons do not require labeling.
- D. Junction Boxes: Label to show system identification, source circuit, or raceway origin. In finished areas, utilize device label. In unfinished areas or above ceilings, use of permanent ink marker is acceptable.
- E. Panel and circuit designation written in permanent marker on the back of the plate and inside all back-boxes and junction boxes.

2.4 WIRE MARKERS

- A. Description: Vinyl-cloth self-adhesive type wire markers.
- B. Locations: Each conductor at panelboard gutters, pull boxes, outlet boxes, junction boxes, and each load connection.
- C. Power and Lighting Circuits: Branch circuit or feeder number as indicated on drawings and source panel.
- D. Control Circuits: control wire number indicated on schematic and interconnection diagrams on drawings or shop drawings.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate designations used on Drawings with equipment nameplates and device labels.
- B. Install nameplates and labels parallel to equipment lines.
- C. Identify empty conduit and boxes with intended use.
- D. Provide typewritten branch panel schedules with protective clear transparent covers accounting for every breaker installed. Use actual room designations assigned by name or number near completion of the work, and not the designations shown on drawings.
- E. Provide color coded boxes as follows:
 1. Fire Alarm: Red.

3.2 EQUIPMENT NAMEPLATES

- A. Degrease and clean surfaces to receive nameplates.
- B. Secure equipment nameplates to equipment front using manufacturer adhesive backing.
- C. Secure equipment nameplates to inside surface of door on panelboard that is recessed in finished locations.

IDENTIFICATION FOR ELECTRICAL SYSTEMS

- D. Verify emergency system distribution equipment nameplate colors with Architect/Owner.
- E. Switchgear, switchboards, sub-distribution switchboards, distribution panels and branch panels to include name, source, voltage, current, phase, wire configuration, and short circuit current rating (SCCR). Transformers to include source, KVA, and secondary voltage, phase, and wire configuration.
- F. Provide nameplates for flush mounted branch panelboards identifying name on front door. On inside of door provide nameplate as noted above. Verify with Architect/Owner if nameplate on outside of door is required.
- G. Provide a second label at branch panelboards listing the means of identification of branch circuit conductors. This identification legend to consist of the color code used for each voltage system (208Y/120V and 480Y/277V). Include identification of both voltage systems on each label, regardless of the voltage of the panelboard to which the label is affixed. Comply with requirements of NEC 210.5.

3.3 DEVICE LABELS

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Degrease and clean surfaces to receive labels. Fingers to be regularly cleaned of grease and debris to prevent fingerprints on labels. Labels installed dirty or with fingerprints to be replaced at no cost to Owner.

3.4 WIRE MARKERS

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Provide wire markers on each conductor for power, control, signalling and communications circuits.

END OF SECTION

This page intentionally left blank

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included: Provision of materials, installation and testing of:

1. Receptacles
2. Finish Plates
3. Surface Covers

1.2 RELATED SECTIONS

A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

B. In addition, provide:

1. Receptacles
2. Wall Plates
3. In-Use Cover

1.5 QUALITY ASSURANCE

A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Receptacles:

WIRING DEVICES

1. Industrial Grade - 20 Amp:
 - a. Cooper 5362
 - b. Hubbell HBL5362
 - c. Bryant BRY5362
 - d. Leviton 5362
 - e. Legrand P&S 5362A
 - f. Or approved equivalent.
 2. Commercial Grade:
 - a. 20 Amp:
 - (1) Cooper 5362
 - (2) Hubbell 5362
 - (3) Bryant CBRS20
 - (4) Leviton 5362S
 - (5) Legrand P&S 5362
 - (6) Or approved equivalent.
 3. Ground Fault Circuit Interrupter (GFCI) Receptacle - 20 Amp:
 - a. Cooper WRS GF20W
 - b. Hubbell GFR5362SGW
 - c. Legrand P&S 2097TRWR
 - d. Or approved equivalent.
- B. Finish Plates:
1. Bryant
 2. Cooper
 3. Hubbell
 4. Leviton
 5. Legrand P&S

WIRING DEVICES

6. Or approved equivalent.
- C. Surface Covers:
1. Aluminum with Gasket, Blanks, Single Gang:
 - a. Bell 240-ALF
 - b. Carlon
 - c. Or approved equivalent.
 2. 2-Gang:
 - a. Bell 236-ALF
 - b. Carlon
 - c. Or approved equivalent.
 3. While-in-Use Weatherproof Cover:
 - a. Die Cast Cover:
 - (1) Intermatic
 - (2) Hubbell
 - (3) Cooper
 - (4) Or approved equivalent.
- D. Provide lighting switches and receptacles of common manufacturer and appearance.

2.2 RECEPTACLES

- A. Duplex Receptacles Characteristics: Straight parallel blade, 125 volt, 2 pole, 3 wire grounding.
1. Commercial Grade: Riveted. Back and side wired. Brass ground contact on steel strap. Nylon face and nylon base. 20 amp.
- B. Ground Fault Circuit Interrupter (GFCI) Receptacle: Feed through type, back-and-side wired, tamper-resistant, weather resistant self-testing, 20 amp, 125VAC.
- C. Special Purpose Receptacles: Reference Drawings for NEMA Standard Specification.
- D. Finish:
1. Grey.

WIRING DEVICES

2. Receptacles installed in surface raceway to match raceway finish. See Section 26 05 33, Raceways.
3. All automatically controlled, nonlocking type, 125 volt, 15 amp and 20 amp rated receptacles to be permanently marked by the manufacturer with the "universal power" symbol and the word "controlled."

2.3 FINISH PLATES

- A. Finish Plates: Type 302 stainless steel with smooth satin finish.
- B. Provide telephone/signal device plates; activated outlets to have coverplates to match modular jack.

2.4 SURFACE COVERS

- A. Material: Galvanized steel, drawn, 1/2-inch raised industrial type with openings appropriate for devices installed on surface receptacles.
- B. Cast Box and Extension Adaptors: Aluminum with gasket, blanks single gang or 2-gang.
- C. While-in-Use Weatherproof Cover: NEMA 3R when closed over energized plug. Vertical mount for duplex receptacle. Provide continuous use cover with cover capable of closing over energized cord cap with bottom aperture for cord exit.
 1. Die cast cover with closed cell neoprene foam gasket: Capable of being locked closed to prevent tampering or unauthorized use.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. See Architectural elevations for location and mounting height of wiring devices. Review Architectural elevations prior to rough-in and contact Architect immediately if conflicts are found between Architectural and Electrical Drawings. Do not rough-in devices until conflicts are resolved.
- B. Install wiring devices and finish plates plumb with building lines, equipment cabinets and adjacent devices. Devices not plumb will be fixed at no additional cost to Owner.
- C. Orientation:
 1. Install wiring devices with long dimension oriented vertically at centerline height shown on drawings or as specified.
 2. Vertical Alignment: When more than one device is shown on drawings in close proximity to each other, but at different elevations, align devices on a common vertical center line for best appearance. Verify with Architect.

WIRING DEVICES

3. Horizontal Alignment: When more than one device is shown on drawings in close proximity to each other with same elevation, align devices on a common horizontal center line for best appearance. Verify with Architect.
- D. Provide labeling per Section 26 05 53, Identification for Electrical Systems.
- E. Test wiring devices to ensure electrical continuity of grounding connections, and after energizing circuitry, to demonstrate compliance with requirements. Test receptacles for line to neutral, line to ground and neutral to ground faults. Correct any defective wiring.

3.2 RECEPTACLES INSTALLATION

- A. Upon installation, adhere to proper and cautious use of convenience receptacles. At time of substantial completion, replace those items which have been damaged, including those burned and scored by faulty receptacles or cord caps.
- B. In the following outlet locations, regardless of whether shown as GFCI on Drawings, either provide a GFCI duplex receptacle, or use a GFCI breaker where code would require a GFCI outlet to have a remote test switch:
 1. Bathrooms.
 2. Where receptacles are installed within 6-feet, 0-inches from edge of sinks.
 3. Kitchens above counters.
 4. On rooftops.
 5. Outdoors.
 6. Where serving vending machines.
 7. Where serving electric drinking fountains.
- C. GFCI Receptacles: One GFCI receptacle may not be used to provide GFCI protection to downstream duplex receptacles on the same branch circuit.

3.3 FINISH PLATES INSTALLATION

- A. Do not install items until finish painting is complete. Replace scratched and paint splattered finish plates and wiring devices.

3.4 SURFACE COVERS INSTALLATION

- A. Do not install items until finish painting is complete. Replace scratched and paint splattered finish plates and wiring devices.

END OF SECTION

This page intentionally left blank

OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:

1. Fuses
2. Molded Case Circuit Breakers

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

B. In addition, provide:

1. Product data and instantaneous let-through current curves and average melting time current curves for fuses supplied to project.
2. Product data and time/current trip curves for circuit breakers supplied to project.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements apply to this Section.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fuses:

1. Bussmann

OVERCURRENT PROTECTIVE DEVICES

2. Ferraz-Shawmut
 3. Littelfuse
 4. McGraw-Edison
 5. Or approved equivalent.
- B. Molded Case Circuit Breakers:
1. Eaton Electrical
 2. ABB/General Electric
 3. Siemens
 4. Schneider Electric/Square D
 5. Or approved equivalent.

2.2 FUSES

- A. Characteristics:
1. Dual element, time delay, current limiting, nonrenewable type, rejection feature.
 2. Combination Loads: UL Class RK1, RK5, or J, 1/10 to 600 amp. UL Class L, above 600 amps.
 3. Motor Loads: UL Class RK5, 1/10 to 600 amp.
 4. Fuse pullers for complete range of fuses.

2.3 MOLDED CASE CIRCUIT BREAKERS

- A. 1-, 2- or 3-pole bolt-on, single handle common trip, 600VAC or 250VAC as indicated on Drawings.
- B. Overcenter toggle-type mechanism, quick-make, quick-break action. Trip indication is by handle position.
- C. Calibrate for operation in 40 degrees C ambient temperature.
- D. 15 to 150 Amp Breakers: Permanent trip unit containing individual thermal and magnetic trip elements in each pole.
- E. 151 to 400 Amp Breakers: Adjustable magnetic trip elements. Provide push-to-trip button on cover of breaker for mechanical tripping.

OVERCURRENT PROTECTIVE DEVICES

- F. Greater than 401 Amp: Electronic trip type with adjustments for long-time, instantaneous, and short-time functions.
- G. Circuit breakers 1200 Amp and Greater: Provide breaker with energy-reducing maintenance switching with local status indicator per NEC Article 240.87(B).
- H. Provide ground fault protection for breakers 1000 amps and greater where applied at 480 volts line-to-line and where indicated on Drawings. Provide ground fault annunciation in lieu of protection, where required, for breakers on emergency (NEC 700) and legally required (NEC 701) systems.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Coordination:
 - 1. Obtain and review the submitted product data for equipment furnished by the Owner, and furnished under other Divisions of this contract, particularly under Divisions 22 and 23.
 - 2. Confirm the equipment nameplate maximum overcurrent protection (MOCP) and make accommodations and adjustments to overcurrent protective devices as necessary to coordinate with the nameplate rating.
- B. Install all items in accordance with manufacturers written instructions.

3.2 FUSES INSTALLATION

- A. Fuses: For each class and ampere rating of fuse installed, provide the following quantities of spares for quantity of fuses installed:
 - 1. 0 to 24: Provide 6 spare.
 - 2. 25 to 48: Provide 9 spare.
 - 3. 49 and Above: Provide 12 spare.

3.3 MOLDED CASE CIRCUIT BREAKERS INSTALLATION

- A. Provide testing of ground fault interrupting breakers.
- B. Provide circuit breakers, as specified and on Drawings, for installation in panelboards, individual enclosures or combination motor starters.
- C. Provide ground fault interrupter circuit breakers for equipment in damp or wet locations.
- D. Provide device on handle to lock breaker in "ON" position for breakers feeding time switches, night lights and similar circuits required to be continuously energized.

OVERCURRENT PROTECTIVE DEVICES

- E. Shunt Trip Circuit Breakers: Provide wiring to remote trip switch/contacts as indicated on Drawings.
- F. Provide multi-pole branch circuit breakers for multiwire branch circuits for simultaneous disconnection of circuits.

END OF SECTION

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included:
 - 1. Toggle Type Disconnect Switches
 - 2. Manual Motor Starters
 - 3. Safety Switches
 - 4. Enclosed Circuit Breakers
 - 5. Molded Case Switches

1.2 RELATED SECTIONS

- A. Contents of Division 26, Electrical and Division 01, General Requirements apply to this Section.
- B. In addition, reference the following:
 - 1. Section 26 28 00, Overcurrent Protective Devices.

1.3 REFERENCES AND STANDARDS

- A. References and Standards as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

- A. Submittals as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.5 QUALITY ASSURANCE

- A. Quality assurance as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

- A. Warranty of materials and workmanship as required by Section 26 00 00, Electrical Basic Requirements and Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Toggle Type Disconnect Switches:

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1. Cooper
 2. Hubbell
 3. Leviton
 4. Legrand (Pass & Seymour)
 5. Slater
 6. Or approved equivalent.
- B. Manual Motor Starters:
1. Eaton Electrical
 2. ABB/General Electric
 3. Siemens
 4. Schneider Electric/Square D
 5. Or approved equivalent.
- C. Safety Switches:
1. Eaton Electrical
 2. ABB/General Electric
 3. Siemens
 4. Schneider Electric/Square D
 5. Or approved equivalent.
- D. Enclosed Circuit Breakers:
1. Eaton Electrical
 2. ABB/General Electric
 3. Siemens
 4. Schneider Electric/Square D
 5. Or approved equivalent.
- E. Molded Case Switches:
1. Eaton Electrical

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

2. ABB/General Electric
3. Siemens
4. Schneider Electric/Square D
5. Or approved equivalent.

2.2 TOGGLE TYPE DISCONNECT SWITCHES

- A. Rating: 120 or 277 volt, 1 or 2 pole, 20 amp, 1 hp maximum.
- B. Enclosure:
 1. NEMA 1: Dry locations/Indoors.
 2. NEMA 3R: Damp or wet locations/Outdoors.
- C. Handle lockable in 'off' position.

2.3 MANUAL MOTOR STARTERS

- A. Quick-Make, Quick-Break. Thermal overload protection. Device labeled with maximum voltage, current, and horsepower.
- B. Enclosure:
 1. NEMA 1: Dry locations/Indoors.
 2. NEMA 3R: Damp or wet locations/Outdoors.

2.4 SAFETY SWITCHES

- A. Heavy duty fusible type and non-fusible type (as indicated on drawings), dual rated, quick-make, quick-break with fuse rejection feature for use with Class R fuses only, unless other fuse type is specifically noted.
- B. Clearly marked for maximum voltage, current, and horsepower.
- C. Operable handle interlocked to prevent opening front cover with switch in 'on' position.
- D. Switches rated for maximum available fault current.
- E. Handle lockable in 'off' position.
- F. Enclosure:
 1. NEMA 1: Dry locations/Indoors.
 2. NEMA 3R: Damp or wet locations/Outdoors.

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

- G. Fusible Switch Assemblies: NEMA KS 1, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse clips: Provide fuse rejection feature for Class R or J fuses up to 600 amp. Remove if circuit breaker type is used. Provide switches of 30 to 200 amp with plug-on line side connections.
- H. Fusible Switch Assemblies, 800 Amperes and Larger: Bolted pressure contact switches. Fuse Clips: Designed to accommodate Class L fuses. Provide with shunt-trip and ground fault capabilities. Remove if circuit breaker type is used.

2.5 ENCLOSED CIRCUIT BREAKERS

- A. Molded case circuit breakers:
 - 1. 1-, 2-, or 3-pole bolt on, single-handle common trip, 600VAC or 250VAC as indicated on drawings.
 - 2. Overcenter toggle-type mechanism, quick-make, quick-break action. Trip indication is by handle position.
 - 3. Calibrate for operation in 40C ambient temperature.
 - 4. 15 to 150 Amp Breakers: Permanent trip unit containing individual thermal and magnetic trip elements in each pole.
 - 5. 151 to 400 Amp Breakers: Variable magnetic trip elements. Provide push-to-trip button on cover of breaker for mechanical tripping.
 - 6. Greater than 401 Amp: Electronic trip type with adjustments for long-time, instantaneous, and short-time functions. Provide ground fault function for breakers greater than 400 amps.
 - 7. Provide handle mechanisms that are lockable in the open (off) position.
 - 8. Circuit breakers to have minimum symmetrical interrupting capacity as indicated on Drawings.
- B. Enclosure:
 - 1. NEMA 1: Dry locations/Indoors.
 - 2. NEMA 3R: Damp or wet locations/outdoors.

2.6 MOLDED CASE SWITCHES

- A. Removable cover, galvanized steel enclosure, powder coat painted.

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

- B. Provide cover padlock provision.
- C. Provide trip unit with no overcurrent, overload, or low level fault protection. Trip unit to be high instantaneous magnetic fixed trip type with magnetic trip reset at factory to interrupt high fault currents at or above preset level.
- D. Enclosure:
 - 1. NEMA 1: Dry locations/Indoors.
 - 2. NEMA 3R: Damp or wet locations/Outdoors.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Obtain and review the submitted product data for equipment furnished by the Owner, and furnished under other Divisions of this contract, particularly under Divisions 22 and 23.
- B. Confirm the equipment nameplate maximum overcurrent protection (MOCP) and make accommodations and adjustments to switches, fuses and circuit breakers as necessary to coordinate with the nameplate rating
- C. Install in accordance with manufacturer's instructions.
- D. Provide engraved nameplates per Section 26 05 53, Identification for Electrical Systems.
- E. Provide arc flash labels per Section 26 05 73, Electrical Distribution System Studies.
- F. Apply neatly typed adhesive tag on inside door of each fusible switch indicating NEMA fuse class and size installed.

3.2 TOGGLE TYPE DISCONNECT SWITCHES

- A. Install fuses in fusible disconnect switches. Coordinate fuse ampere rating with installed equipment. Do not provide fuses of lower ampere rating than motor starter thermal units.
- B. Install products, systems and equipment in accordance with manufacturer's written instructions and requirements.
- C. See General Installation Requirements above.

3.3 MANUAL MOTOR STARTERS

- A. Provide disconnecting means within sight of each motor controller and of each motor. Motor controller disconnecting means equipped with lock-out/tag-out padlock provisions do not require a disconnect switch at the controlled motor location. Locate disconnect means in view of and not inside of equipment, such that tools are not needed to remove covers to access the disconnecting means.

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

- B. Install products, systems and equipment in accordance with manufacturer's written instructions and requirements.
- C. See General Installation Requirements above.

3.4 SAFETY SWITCHES

- A. Install products, systems and equipment in accordance with manufacturer's written instructions and requirements.
- B. See General Installation Requirements above.

3.5 ENCLOSED CIRCUIT BREAKERS

- A. Install products, systems and equipment in accordance with manufacturer's written instructions and requirements.
- B. See General Installation Requirements above.

3.6 MOLDED CASE SWITCHES

- A. Install products, systems and equipment in accordance with manufacturer's written instructions and requirements.
- B. See General Installation Requirements above.

END OF SECTION