

**University of South Carolina  
Career Center at Thomas Cooper Library  
Columbia, SC**

University Project No. H27-I998-A  
Architect's Project No. 12.130.03  
Addendum No. 1

Quackenbush Architects + Planners  
1217 Hampton Street  
Columbia, South Carolina 29201

April 10, 2013

**ADDENDUM NO.1**

The following items shall take precedence over the drawings and specifications for the above named project and shall become a part of the contract documents. Where any item called for in the specifications, or indicated on the drawings, is not supplemented hereby, the original requirements shall remain in effect. Where any original item is amended, voided or superseded hereby, the provisions of such item not specifically amended, voided or superseded shall remain in effect.

**ATTACHMENTS**

Documents:

**GENERAL**

1. Bidders are hereby advised that information from bid documents which are not received from the sources listed in the Invitation for Bids is not legitimate and the bidder accepts full responsibility for any differences. Quackenbush Architects + Planners has not authorized the scanning of their documents. Bidders should be aware that the plans are copyrighted and any unlawful use is subject to legal action. Bidders are further advised that the purchase and/or use of partial bid documents is not recommended and bidder will be responsible for any discrepancies which might have been avoided had a full set of documents been reviewed.
2. Listing of multiple products or manufacturers within specifications or approval of products or manufacturers via substitution request does not waive or preclude any and all performance, warranty or specific requirements listed within the specification unless specifically noted in the Addendum. Only manufacturers and products meeting the specification requirements and listed in the specifications or included in the Addendum shall be approved for the project.

**A. CHANGES TO TECHNICAL SPECIFICATIONS AND DRAWINGS:**

**SPECIFICATIONS**

**Item No.    Description**

1.            Please note the following specification sections have been added to the project manual to match the table of contents originally submitted. They are as follows:

**DIVISION 22 PLUMBING**

220500 Plumbing

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

230500 Mechanical and Electrical General Provisions

230530 Basic Materials and Methods

230548 Mechanical Vibration, Sound and Seismic Controls

230593 Testing and Balancing

230700 Mechanical Systems Insulation

233110 Air Distribution

238120 Heating and Air Conditioning Equipment

**DIVISION 26 ELECTRICAL**

260519 Low-Voltage Electrical Power Conductors and Cables

260526 Grounding and Bonding for Electrical Systems

260529 Hangers and Supports for Electrical Systems

260533 Raceways and Boxes for Electrical Systems

260544 Sleeves and Sleeve Seals for Electrical Raceways and Cabling

260548 Vibration and Seismic Controls for Electrical Systems

260553 Identification for Electrical Systems

262416 Panelboards

262726 Wiring Devices

265100 Interior Lighting

**DIVISION 28 ELECTRONIC SAFETY AND SECURITY**

283111 Digital, Addressable Fire-Alarm System

**DRAWINGS**

**Item No.    Description**

1.            None

END OF ADDENDUM NO.1

## SECTION 220500 - PLUMBING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

#### 1.2 SCOPE

- A. This section includes the storm, soil, waste, drain, vent and domestic water systems from their source of supply or point of disposal to and including their connection to equipment and fixtures.
- B. The requirements of Division 23, Sections "Mechanical and Electrical General Provisions" shall apply to all work specified under this section. Sterilization shall comply with Section 610 of the 2009 International Plumbing Code.

#### 1.3 CODES

- A. All plumbing work shall comply with the 2009 International Plumbing Code and the regulations of the South Carolina Department of Health and Environmental Control (DHEC), and the State of South Carolina. Obtain all approvals before starting plumbing work. Request all inspections during the course of work.
- B. Installation shall meet the regulations contained in the Safe Drinking Water Act (SDWA) concerning lead and copper concentrations.
- C. All residential type faucets, electric water coolers and drinking fountains shall meet the requirements of NSF Standard 61, Section 9.

#### 1.4 EQUIPMENT CONNECTIONS

- A. Provide all plumbing connections required by equipment which is provided on this project. Certain items of equipment shall be provided under this section and certain items will be furnished and set under other sections of the specifications. In all cases, provide valved water supplies, waste and vent lines, and, unless noted otherwise, make final connections after equipment is in place.

## PART 2 - PRODUCTS

### 2.1 PIPE, VALVES AND FITTINGS

- A. Provide materials as hereinbefore specified in Division 23, Section "Basic Materials and Methods". All floor, wall and ceiling penetrations for piping shall be sealed with appropriate sealant.
- B. Unions or flanges shall be provided at all connections to each piece of plumbing equipment and on both sides of valves and other in-line devices that require removal for maintenance. Bronze adaptors shall be used at all copper to flanged or IPS connections.

### 2.2 PLUMBING FIXTURES

- A. Provide all plumbing fixtures indicated on the drawings and as specified herein. All exposed metal parts of all fixtures, including all trim and fittings, shall be brass, chromium plated. Each hot and cold water connection to each fixture shall be provided with a stop valve and all nipples shall be chrome plated red brass. Provide backflow devices on all faucets and fittings requiring same. Devices may be inline type when not provided integral with the faucet. All faucet handles, where possible, shall have color coded "indexes" identifying the service used. All "serrated" or slip hose connection spout outlets shall have Allen wrench operated volume controls to control "splashing" of water as it hits sink bottoms. Water supplies for handicapped lavatories and sinks shall be insulated. Waste line for handicapped lavatories and sinks shall be offset and insulated. Refer to Division 23, Section "Mechanical Insulation" for insulation type and thickness.
- B. Water supplies for handicapped water closets shall be roughed-in for flush valve handles to be operated from the accessible side of the water closet. The Contractor shall coordinate and provide flush handles on the accessible side of all handicapped water closets. Provide offset flush connection as required to coordinate with wall mounted grab bars" to all ADA water closets with flush valves.
- C. The Contractor shall provide metal supports necessary to adequately and substantially hang and set all fixtures subject to the approval of the Architect. No wood grounds, wood plugs, or expansion bolts shall be permitted for fixture support. Provide carriers where specified below and as required to hang fixtures.
- D. Insulate all exposed piping under lavatories and sinks with a white, fitted/molded antimicrobial undersink pipe cover equal to Truebro Lav Guard 2. Cover shall have internal, E-Z Tear-To-Fit trim feature for square, clean trimming (internal ribs) and built-in, concealed E-Z Grip fasteners (no cable-tie fasteners allowed).
- E. Water-Conserving Fixtures: Plumbing fixtures and fittings shall use in aggregate at least 30% less water than the water use baseline calculated for the building after meeting the Energy Policy Act of 1992 fixture performance requirements. Flow and flush rates shall not exceed the following:

1. Toilets: no more than 1.3 gallons per flush and have documented bowl evacuation capability per MaP testing of at least 400 grams.
2. Urinals: no more than 0.5 gallons per flush or use.
3. Lavatory Faucets: 0.5 gpm with automatic faucet controls.
4. Showerheads: no more than 1.5 gpm.

F. Acceptable Manufacturers

1. Fixture shall be American Standard, Crane or Kohler, equal to American Standard or other manufacturer of the types listed below.
2. Flush valves shall be Zurn, Sloan, Delany or Cambridge Brass, equal to Sloan of the types listed below.
3. Faucets shall be Sloan, Kohler, Chicago Faucet, T & S Brass, Crane, Eljer or American Standard equal to Sloan of the types listed below.
4. Drinking fountains shall be Elkay, Oasis or Halsey Taylor equal to Elkay of the types listed below.
5. Toilet seats shall be Bemis (Church), Beneke, Sperzel equal to Church of the types listed below.

G. Fixtures:

1. P-1 Kitchen Sink:

- Fixture: American Standard 20SB.251900.073, 20 gauge stainless steel, single bowl undermount sink, nominal dimensions 24 3/4 "x18 3/4 "x8"
- Faucet: American Standard 4275.550, two handle kitchen faucet brass construction with all brass inlet shanks and coupling nuts. Brass gooseneck swivel spout. Shall also feature 1/4 turn washerless ceramic disc valve cartridges that are reversible for use on either hot or cold side.
- Strainer: McGuire 1518 Heavy duty forged brass basket strainer with brass basket. Furnished with 1 1/2"x8" tailpiece, brass lock and coupling nuts.
- Trap: McGuire 8912CNC Heavy cast brass 1 1/2 x 1 1/2" adjustable trap with no cleanout plug and 12 inch center to end. Furnished with slip nuts, seamless tubular brass wall bend and steel shallow flange.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF PIPING

#### A. Interior Drainage Systems:

1. Soil, waste, vent, and drain piping for sanitary and storm drainage, shall be of the sizes noted, and shall be run as indicated. Pipes must be run in straight lines and have a uniform grade between elevations noted. No branch drain shall have a grade less than that indicated for the main drain to which it is connected. Where elevations are not given, horizontal pipes shall have a uniform grade of 1/4 inch per foot where possible but in no case less than 1/8 inch per foot and shall be installed to the inverts shown. All piping shall be adequately supported as specified in Division 23, Section "Mechanical and Electrical General Provisions". All main vertical soil and waste stacks shall be extended as vents full size to approximately 18 inches above the roof of the building. Two (2) or more vent lines shall be connected together where practicable and extended as one (1) pipe through the roof. Vent pipes in roof spaces shall be run as close as possible to the underside of the roof without forming traps in pipes. Vent pipes may be connected to other vent pipes or to main vent stacks provided the connections are at least four (4) feet above the floor on which the fixtures are located so that no vent pipe can be used as a waste. Openings in roof for vent pipes shall be flashed and made watertight. Use vent stack flashing sleeves where applicable. Handicapped plumbing fixtures shall be rough-in to suit the specific mounting of the fixture. Waste lines shall be offset for lavatories and sinks to accommodate wheelchair type strainers and traps shall be insulated.
2. Changes in direction shall be made by appropriate use of forty-five (45) degree wyes, 1/2 wyes, or long sweep 1/4, 1/6, 1/8, or 1/16 bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where change in direction of flow is from horizontal to vertical; except use long turn tee wyes when two (2) fixtures have common drain. Straight tees, elbows, and crosses may be used on vent lines. Make no change in direction of flow greater than ninety (90) degrees. Where different sizes of drainage pipes or pipes and fittings are to be connected, use standard increasers and reducers of proper size. Reduction of size in horizontal drainage piping in direction of flow is prohibited.
3. Drilling and tapping of drains, soil, waste, or vent piping, and use of saddle hubs and bands are prohibited.
4. Connect piping to fixtures or equipment by couplings or unions so that devices may be replaced with no disturbance to piping.

#### B. Water Piping Systems:

1. Water piping shall be complete from service connection to all fixtures, equipment, outlets, etc. Sizes of pipes shall be shown or as specified.
2. Chromium plated piping shall be threaded and made up carefully, and not more than one (1) full turn of thread shall be exposed beyond any fitting.
3. Ends of pipes or tubing and recesses of fittings to be bronzed or soldered shall be thoroughly cleaned. Joints shall be assembled without binding. Brazing material or solder shall penetrate fully and shall fill the joint completely.
4. All brass and copper pipe and tubing shall be free from cuts, dents or other surface

damage at the time of final inspection. Damaged pipe or tubing shall be removed and replaced with new pipe or tubing.

5. Horizontal runs of brass and copper pipe and tubing over fifty (50) feet in length shall be anchored to wall or floor construction. Anchors shall be located near the midpoints of the runs so as to force the expansion equally to the ends or in a direction where expansion can take place without excessive strain. Swing joints, offsets, expansion joints, etc., shall be provided where necessary to accommodate expansion of piping, which will be approximately two (2) inches in 100 feet of brass or copper hot water piping.
6. Where non-ferrous metal piping and zinc-coated metal piping are jointed, dielectric (insulating) couplings, fittings or unions shall be provided.
7. Where pipe sizes shown or specified differ from the connection sizes of meters, pumps, fixtures, outlets, etc., reducing fittings shall be installed.
8. Water supplies for wall hung lavatories shall be roughed in as high as possible and still permit connections to the faucet. Water supplies shall be insulated for handicapped fixtures and rough-in shall be on accessible side of fixture for flush valves and flush handles.

- C. All rough-in plumbing shall be sealed off with test plugs, caps, etc., until fixtures are ready to be installed.

### 3.2 TRAPS

- A. Each fixture, floor drain and piece of equipment connected to the sanitary system shall be equipped with a trap.
- B. Provide traps for storm water lines where required by code.
- C. Each trap shall be placed as close to the fixture as possible and no fixture shall be double trapped.
- D. All traps on bell and spigot pipe shall be extra heavy cast iron and all traps on threaded pipe shall be galvanized cast iron recessed drainage type.

END OF SECTION 220500

## SECTION 230500 – MECHANICAL AND ELECTRICAL GENERAL PROVISIONS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

#### 1.2 SCOPE

- A. This Section describes the general provisions for the fire protection, plumbing, mechanical and electrical work included in Divisions 21, 22, 23 and 26 respectively. This section applies to all sections of Divisions 21, 22, 23 and 26. Refer to Division 26 for additional General Provisions related to electrical work.
- B. Contractor shall obtain and pay for all installation permits, certificates, and inspection fees relative to the work. The preparation of any specific plans or shop drawings necessary to obtain these permits shall also be the responsibility of the contractor.

#### 1.3 RESPONSIBILITY

- A. The General Contractor shall be responsible for all work included in the Mechanical, Electrical, Plumbing and Fire Protection Divisions. The delegation of work to Subcontractors shall not relieve him of this responsibility. Subcontractors who perform work under these Sections shall be responsible to the General Contractor. The term "Contractor" is used throughout this Division and shall mean the General Contractor, although the actual performance of the work may be by a Subcontractor.
- B. Within thirty (30) days after award of the contract, the Contractor shall submit to the Architect, for approval a list of all subcontractors' names he proposes to use.
- C. The Contractor shall carefully review all divisions of the project specifications. Where conflicts exist between divisions and/or sections of the specifications the most stringent requirement as determined by the Architect shall apply.
- D. The contractor shall obtain and pay for all installation permits, certificates, and inspection fees relative to the work. The preparation of any specific plans or shop drawings necessary to obtain these permits shall also be the responsibility of the contractor.



#### 1.4 REFERENCES AND DEFINITIONS

Following are definitions of terms and expressions used in the Mechanical and Electrical Sections:

Provide	- furnish and install
Directed	- directed by the Architect
Indicated	- indicated in Contract Documents
Concealed	- hidden from normal sight; includes items within furred spaces, pipe and duct shafts, above suspended ceilings and within return air plenums.
Exposed	- non concealed - Work within Equipment Rooms shall be considered exposed.
Exterior	- items being or situated outside. Items located within a crawl space shall be considered exterior.
Conditioned	- a heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means, so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.
Piping	- includes pipes, fittings, valves, hangers, and accessories comprising a system
Ductwork	- includes ducts, fittings, housings, dampers, hangers, air devices, and accessories comprising a system.

#### 1.5 STANDARD SPECIFICATIONS

- A. See Division 1 - General Requirements.
- B. References to catalogs, standards, codes, specifications, and regulations apply to the latest edition in effect at the date of the invitation to bid.

#### 1.6 CODES, REGULATIONS, AND PERMITS:

- A. Give all necessary notices, obtain all permits, and pay all fees and other costs, including those for utility connections or extensions in connection with the work. File all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments having jurisdiction. Obtain all required certificates of inspection and deliver same to the Architect before request for acceptance and final payment for the work.
- B. All materials furnished and all work installed shall comply with the latest rules, regulations, and recommendations of the following bodies:

- 2009 International Building Code with State of South Carolina Supplements
- 2009 International Existing Building Code with State of South Carolina Supplements
- 2009 International Mechanical Code with State of South Carolina Supplements
- 2009 International Plumbing Code with State of South Carolina Supplements
- 2009 International Fire Code with State of South Carolina Supplements

2006 International Energy Code with State of South Carolina Supplements  
National Electric Code, 2008 Edition  
National Fire Protection Association Standards (Latest Editions)  
State Fire Marshal Regulations  
Fire Prevention Bureaus of Mount Pleasant, the City of Charleston, Charleston County  
and the State of South Carolina  
ASHRAE Standards and Handbooks (Latest Editions)  
Local Health Department  
State Health Department  
Local Utility Companies  
Underwriters Laboratories  
Owner's Insurance Underwriter Standards  
Environmental Protection Agency

#### 1.7 MATERIALS LIST AND SHOP DRAWINGS

- A. See Division 1, GENERAL REQUIREMENTS for Additional Requirements related to submittals and shop drawings.
- B. Prior to delivery of any material or equipment to the job site; submit for approval, dimensioned drawings or cuts showing construction size, arrangement, operating clearances, performance characteristics, and capacity of material or equipment. Each item of equipment proposed shall be a standard catalog product of the approved manufacturer. Submittals shall be received early in the construction period to allow the Architect ample time for review and checking for compliance with the contract documents. The Architect will be expected to process a maximum of ten (10) submittals in a five (5) day working period. The Contractor shall carefully schedule the submission time of all submittals to insure that approvals will be received to meet the critical path of the construction project.
- C. If the Contractor's submittals, upon review by the Architect, do not conform to the requirements of the contract documents, the contractor shall be required to resubmit with modification, within fifteen (15) working days of receipt of the Architect's notification and comments to the Contractor. The Contractor shall be responsible for the extra expenses for subsequent review of rejected or revised submittals necessitated by the Contractor's failure to provide a complete and accurate submittal meeting the requirements of the contract documents. Such extra fees shall be deducted by the Owner from payments to the Contractor.
- D. Samples, drawings, specifications, catalogs, etc., submitted for approval shall be properly labeled indicating specific item, model number, and service for which material or equipment shall be used. Section and article number of specifications governing, Contractor's name, name of job, and date and also be clearly indicated on all submittals. Submittals that are not properly labeled or identified will be returned marked "Not Reviewed".
- E. Catalogs, pamphlets, or other documents submitted to describe items on which approval is being requested shall be specific. Identification in catalog, pamphlet, etc., of item submitted shall be clearly made in ink. Data of a general nature will not be accepted.

- F. If material or equipment is installed prior to receipt by the Contractor of pertinent shop drawings marked "No Exceptions Taken" or "Comments Noted", the Contractor shall be liable for its removable replacement at no extra charge to the Owner.
- G. Prepare and submit shop drawings for all specifically fabricated items, modifications to standards items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.
- H. Submit data and shop drawings as listed below, in addition to provisions of paragraphs above. Identify all shop drawings by the name of the item and system and applicable specification paragraph number.

Shop Drawings:

Section 210500 – Fire Protection

Fire Hose Cabinets

Section 220500 – Plumbing

Plumbing Fixtures

Section 230500 – Mechanical and Electrical General Provisions

Record Drawings

Installation and Coordination Drawings

Pipe and Conduit Hangers and Supports

Sleeves and Penetrations Drawings

Operation and Maintenance Manuals

List of Manufacturers' Material and Equipment

Section 230530 – Basic Materials and Methods

Hangers and Pipe Shields

Identification Items

Pipe, Fittings, and Joints

Balancing Valves

Butterfly Valves

Ball Valves

Drain Valves

Gate and Globe Valves

Check Valves

Manual and Automatic Air Vents

Pressure Regulating and Relief Valves

Backflow Preventers and Vacuum Breakers

Strainers

Temperature Wells

Pressure Gauges

Thermometers  
Test Plugs  
Steam Traps  
Steam Vacuum Breakers  
Steam Relief Valves  
Expansion Joints  
Pipe Guides  
Dielectric Fittings  
Unions  
Test Reports  
Sterilization Report

Section 230548 – Mechanical Vibration, Sound and Seismic Controls

Vibration Isolation and Seismic Restraint Components

Section 230550 – Variable Frequency Drives (VFDs)

Variable Frequency Drives

Section 230593 – Testing and Balancing

Test Reports

Section 230700 – Mechanical Systems Insulation

All Insulation Types  
Adhesives, Sealers, and Coatings  
Fabric Jackets  
Fitting and Valve Covers  
Metallic Components  
Insulated Pump Covers

Section 233110 – Air Distribution

Air Terminal Units  
Air Devices  
Insulated Metal Casings  
Sound Attenuators and Certified Test Data  
Air Filters and Holding Frames  
Dampers:  
    Fire  
    Fire/Smoke  
    Smoke  
    Volume  
Ductwork  
Medium Pressure Ductwork Samples  
Duct Lining  
Air Measuring Devices

Fans  
Roof Ventilators and Penthouses  
Louvers  
Duct Heaters

#### Section 238120 – Heating and Air-Conditioning Equipment

##### Electric Baseboard Heating

- I. Contractor, additionally, shall submit for approval any other shop drawings as requested by the Architect. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Architect.

#### 1.8 EQUIPMENT START-UP AND INITIAL OPERATION

- A. No equipment shall be operated, for testing or trial use, before full compliance with the equipment manufacturers' specifications and instructions for the lubrication, alignment, direction of rotation, balance, and other applicable considerations.
- B. Particular care shall be taken to see that all equipment is completely assembled, properly lubricated, and all grease and oil cases and reservoirs have been filled to the correct level with the recommended lubricants.
- C. It is the Contractor's responsibility to place each item of equipment, installed by him, in operating condition. This responsibility includes all auxiliaries, piping, wiring, etc., the start up of each unit, and a check of its performance.

#### 1.9 WARRANTY

- A. The Contractor shall warranty, by his acceptance of the Contract, that all work installed, by him or his subcontractors, will be free from defects, in workmanship and materials, for a period of one (1) year after the date of certification of completion and acceptance of work. Any defects in workmanship, materials or performance which appear within the guarantee period shall be corrected by the Contractor, without cost to the Owner, within a reasonable time to be specified in notice from the Architect. In default thereof, Owner may have such work done and charge the cost of same to the Contractor.

#### 1.10 SITE VISIT

- A. Prior to preparing the bid, the Contractor and subcontractors shall visit the site and familiarize themselves with all existing conditions, make all necessary investigations as to locations of utilities, and all other matters which can affect the work. No additional compensation will be made to the Contractor as a result of his failure to familiarize himself with the existing conditions under which the work must be performed.

1.11 DRAWINGS

- A. The Contract Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Any offsets, rises, or transitions not shown on the drawings and required to provide a complete system shall be provided at no additional contract cost. Do not scale the drawings. Consult the Architectural and Structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

1.12 RECORD DRAWINGS

- A. Contractor shall keep accurate records of all deviations in work, as actually installed, from work indicated.
- B. When work is complete, make two (2) complete "Record" sets of marked-up prints, certify the accuracy of each print by endorsement and signature thereon. Deliver same to the Architect who will, after approval, deliver these two (2) sets to the Owner.
- C. All underground work shall be accurately located on record drawings by plan dimension and elevation. Such work shall include utilities, storage tanks, plumbing pipes, etc.

1.13 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a minimum period of four (4) days of eight (8) hours each, or as otherwise specified. During this period, Contractor shall instruct the Owner's representative fully in the operation, adjustment, and maintenance of all equipment furnished. At least forty-eight (48) hours in advance written notice shall be given to the Owner.
- B. Contractor shall furnish to the Architect four (4) complete bound sets of typewritten or blueprinted instructions for operating and maintaining all systems and equipment included in this Contract. Operating and maintenance manuals shall include all construction test reports, final balancing reports, valve tag schedule, final inspection certificates, and occupancy permits. Also provide two (2) complete bound sets of approved shop drawings for all items of equipment utilized on the project. All instructions shall be submitted in draft for approval prior to final issue. Manufacturers' advertising literature or catalogs will not be acceptable for operating and maintenance instructions.
- C. Instructions shall include a general description of each system and specific instructions describing routine and emergency procedures required of the building personnel for operating and maintaining each system. The instructions shall include the name or label, location, and function of all operating equipment and controls, such as start-stop switches, time clocks, and safety and temperature controllers. Operating modes and the procedures for indexing each mode shall be clearly described. A listing of names, addresses, and phone numbers of the service organizations for each item of equipment and a typewritten maintenance schedule for same shall be included.

- D. The instructor shall be thoroughly familiar with all parts of the installation on which he is to give instruction. The instructor shall be trained in operating theory as well as practical operation and maintenance work. Employ factory trained instructors for automatic temperature control systems and wherever else necessary, as determined by the Architect.
- E. During the warranty period, the Contractor shall service and maintain all equipment, excluding filter replacement, provided under this contract. Prior to the start of guarantee period, the Contractor shall provide the Owner with a schedule of required maintenance operations for each system and items of equipment. Contractor shall submit schedule to the Architect for approval. Thereafter, monthly reports shall be submitted to the Owner describing actual service provided. Forty-eight (48) hours advance notice shall be given to the Owner, prior to work required under this Section.
- F. Contractor shall provide the Owner with all tools required to service and maintain all equipment.

#### 1.14 ELECTRICAL WORK

- A. Under Divisions 22 PLUMBING and 23 MECHANICAL, provide the following items of electrical work which shall conform with the applicable requirements of the Electrical Division:
  - 1. Low voltage temperature control wiring.
  - 2. Interlock wiring for mechanical equipment and devices.
- B. Under Division 26 ELECTRICAL, provide:
  - 1. Power wiring, complete from power source to motor or equipment junction box, including power wiring through motor starters, power factor correction devices, and line reactors. Power factor correction devices shall be provided under Division 23 and installed under Division 26.
  - 2. Motor control centers or motor starter, panelboards.
  - 3. All miscellaneous individual motor starters, unless noted or specified otherwise.
- C. Variable frequency drives and chiller motor starters will be furnished and set in place under Division 23. Power wiring shall be provided under Division 26

#### 1.15 SINGULAR NUMBER

- A. Where any device or part of equipment is herein referred to in the singular number (such as "valve"), such reference applies to as many such devices as are required to complete the installation as shown on the drawings.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. All materials shall be new, the best of their respective kinds, suitable for the conditions and duties imposed on them at the building, and shall be of reputable manufacturers'. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the sections following.
- B. See Division 1 - General Requirements. All component parts of each items of equipment or device shall bear the manufacturers' name plate; giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc., in order to facilitate the maintenance or replacement. The name plate of a subcontractor or distributor will not be acceptable. Where Underwriters' Laboratories standards apply, material and equipment shall be approved by them and shall bear the UL Label.
- C. In specifying materials, three (3) general procedures are used. The three (3) classifications are as follows:

GROUP 1: When a material or equipment is specified by brand name or other identifying information and three (3) or more brands are named it is considered that any one (1) of the brands so named will perform as desired, and the Contractor shall base his proposal on one (1) of the named brands. The first brand named or identified basis of design shall be used as a standard. The other brands named shall be equal to the specified brand in all respects. If one (1) of the other brands named is used it shall be the Contractor's responsibility to verify proper clearances and fit of the substituted equipment.

GROUP 2: When the material or equipment is specified with the phrase "...or approved equal..." after a brand name and other identifying information, it is intended that the brand name is used for the purpose of establishing a minimum acceptable standard of quality and performance and Contractor may base his bid proposal on any item which is in all respects equal to that specified and presents essentially the same appearance. It shall be the Contractor's responsibility to ensure proper fit and clearances of all substituted equipment.

GROUP 3: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, American Society of Testing and Materials, government specifications, etc. the Contractor shall base his proposal on any item which can be shown to comply in all respects to the referred "Standard Specification".

- 1. It is distinctly understood: (1) that the Architect will use his own judgment in determining whether or not any materials, equipment or methods offered in substitution are equal to those specified; (2) that the decision of the Architect on all such questions of equality is final; and (3) that all substitutions will be made at no increase in cost to the Owner.
- 2. Upon receipt of written approval from Architect, Contractor may proceed with substitution providing Contractor assumes full responsibility for, and makes, at his own expense, any changes or adjustments in construction or connection with other work that



may be required by the substitution of such materials, equipment or methods. In the event of any adverse decisions by the Architect no claim of any sort shall be made or allowed against the Owner.

## 2.2 INSTALLATION AND COORDINATION DRAWINGS

- A. Prepare, submit and use composite installation and coordination drawings to assure proper coordination and installation of work in all buildings. No installation or construction work shall begin until the coordination drawings are completed, submitted, and approved. Drawings shall include, but not be limited to, the following:
  - 1. Complete Roof, Floor, Interstitial and Crawl Space Plans, including all exterior equipment
  - 2. Mechanical Rooms in the Building
  - 3. Mechanical Shafts
  - 4. Pipe sleeves, equipment pads, etc.
- B. Show relationship and integration of different construction elements that require coordination during fabrication or installation to fit in space provided and function as intended.
- C. Prior to fabricating or installing work, prepare composite coordination drawings at appropriate scale; detail major elements, components, and systems of architectural, structural, mechanical, and electrical such as equipment, components, and materials in relationship with each other, installations, and building components. Include dimensions. Composite coordination drawings shall include new and existing elements, components, and systems.
- D. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are important to efficient flow of Work.
- E. Indicate scheduling, sequencing, movement, and positioning of large equipment into building during construction.
- F. Assembly Penetrations: Prepare drawings as required to indicate penetrations in floors, walls, and ceilings and their relationship to assembly construction, other penetrations and installations. Identify where additional bracing and offsets are required to comply with Contract Documents.
- G. Prepare drawings as required to coordinate and integrate ceiling installations, air outlets and inlets, light fixtures, communications systems components, sprinklers, other ceiling-mounted devices, components located above suspended ceilings, and suspended ceiling support components.
- H. Show interrelationship of components indicated on separate Shop Drawings.
- I. Indicate required installation sequences to minimize cutting and patching.
- J. In addition, prepare coordination drawings required below and in other Specification sections.
- K. Mechanical Systems: Include, but do not necessarily limit to, the following:

1. Proposed locations of piping, ductwork, equipment, and materials.
  2. Proposed locations for access panels and doors.
  3. Clearances for installing and maintaining insulation.
  4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance. Show access locations.
  5. Equipment connections and support details, including vibration isolation, seismic and sway bracing.
  6. Exterior wall, roof and foundation penetrations.
  7. Fire-rated wall and floor penetrations.
  8. Sizes and location of required concrete pads and bases.
  9. Valve stem movement.
- L. Draw plans to a scale not less than 1/4 inch equals one (1) foot. Include plans, sections, and elevations of proposed work, showing all equipment, piping and ductwork in areas involved. Fully dimension all work horizontally and vertically. Show coordination with other work including sprinklers, lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.
- M. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to be factory-wired terminals include manufacturer's literature showing internal wiring.
- N. Installation and coordination drawings shall be produced on an AutoCad format. Reproduction of any portion of the mechanical and electrical contract drawings for re-submittal as a shop drawing is strictly prohibited. Shop drawings produced in such a manner will be rejected and returned not reviewed. Installation and coordination drawings shall be to scale reflecting actual equipment sizes purchased for the project.
- O. The "Base" architectural and structural background drawings will be provided on Autocad format by the Construction Manager/General Contractor. These "Base" background documents are to be provided to each Contractor in the coordination process to establish a common platform for each Contractor to use for their design drawings. This same information will be used to communicate their respective coordination with the other Contractors. Coordination will be accomplished by each Contractor superimposing his work on drawings in the following sequence:
1. Construction Manager/General Contractor - Base Drawings indicating structural steel with elevations for bottom of beams & finish floor. The general contractor shall include a layout of ceiling tiles (where applicable).
  2. HVAC Contractor - Ductwork layout drawings & piping with elevations to bottom of ductwork & piping. HVAC contractor shall indicate location of all registers, diffusers and grilles.
  3. Plumbing Contractor - Layout of all piping with elevations.
  4. Sprinkler Contractor - Layout of all piping & heads with elevations.
  5. Electrical Contractor - Conduit layout with junction boxes and location of all electrical fixtures.

- P. If necessary, Contractor coordination meetings shall be held continuously until the coordination drawings are complete and approved by all parties. Any conflicts, etc., discovered in the coordination stages prior to Contractor(s) sign-off which cannot be resolved by the Contractor(s) shall be brought to the Architect's attention for resolution.
- Q. Any conflicts, etc., discovered after the created and submission of the coordination and installation drawings and during the installation of the Work will be the responsibility of the Contractor(s) to resolve with the approval of Architect. Any and all costs for these resolutions shall be solely the responsibility of the Contractor(s).
- R. Work fabricated/installed prior to the completion of the coordination and installation drawings is performed at the Contractors own risk, and compensation of time/costs for corrections will not be awarded. Any work installed that is not in conformance with final approved coordination and installation drawings shall be required to be removed and relocated, and compensation of time/costs for corrections will not be awarded.
- S. Each Contractor is responsible for timely updates to the coordination drawings to indicate as-built conditions for their own work. Updates are required to include all changes regardless of the source or reason for the change, including changes initiated by the Owner, Architects or Engineers.

## 2.3 PIPING, CONDUITS, AND SUPPORTS, GENERALLY

- A. Piping and conduits, except electrical conduits run in floor construction, shall be run parallel with the lines of the building, unless otherwise shown or noted on the drawings. Electrical conduits shall not be hung on hangers with any other service pipes. The different service pipes, valves, and fittings shall be so installed that after the covering is applied there will not be less than 1/2 inch clear space between the finished covering and other work and between the finished covering and parallel adjacent pipes. Hangers on different service lines, running parallel with each other and nearly together, shall be in line with each other and parallel to the lines of the building. Exact location of sprinklers, electrical outlets, piping, ducts, and conduits shall be coordinated among the trades so that there will be no interference between lighting fixtures, piping, ducts, and conduits. Where conflicts between the trades result, they shall be resolved by the Contractor to the Architect's satisfaction and at no expense to the Owner.
- B. Hangers shall be spaced to prevent sag and permit proper drainage. Refer to Division 23, Section "Basic Materials and Methods" for hanger spacing. A hanger shall be placed within one (1) foot of each horizontal elbow. See drawings for any additional hanger requirements.
- C. Vertical runs of pipe and conduit less than fifteen (15) feet long shall be supported by hangers placed one (1) foot or less from the elbows on the connecting horizontal runs. Vertical runs of pipe and conduit over fifteen (15) feet long, but not over sixty (60) feet long, and not over six (6) inches in size, shall be supported by heavy steel clamps. Clamps shall be bolted tightly around the pipes and conduits and shall rest securely on the building structure without blocking. Clamps may be welded to the pipes or placed below coupling.
- D. Hangers and support devices shall be by Anvil International , Unistrut, Fee & Mason, Elcene, Kindorf, Mueller or Auto-Grip. Unless otherwise specified, or indicated on the drawings, pipe

and conduit hangers and hanger supports shall conform to the following Anvil International figures.

1. Hangers generally shall be Figs. 65, 104, 212, 260 and 295.
  2. Hanger Figs. 212 and 295 shall be provided with turnbuckles and eye rods or rods with eye nuts.
  3. Turnbuckles shall be Figs. 114 or 230, shall have not less than 1-1/2 inches of adjustment, and shall be provided with locknuts.
  4. Brackets Figs. 194, 195, and 199 shall be used for support of pipe hangers on lines larger than four (4) inches run along walls near floors.
  5. Riser clamps shall be Figs. 261 or CT-121.
  6. Roller hangers Figs. 171, 175, 177 and 181 shall be used for steam and condensate piping two (2) inches and larger and wherever the movement of pipe due to expansion exceeds 3/4 inch per foot of hanger rod lengths.
  7. Roller supports shall be adjustable, Anvil International Fig. 274 for installation of hot service piping over two (2) inches in size and installed in racks or on trapeze hangers.
  8. Concrete inserts shall be Figs. 281 or 282.
  9. On copper pipes, hangers in contact with pipe shall be copper plated.
- E. In lieu of individual hangers, multiple (trapeze) hangers may be used for water pipes having same elevation and slope and for electrical conduits as specified hereinafter:
1. Horizontal members shall consist of 1-1/2 inch by 1-1/2 inch twelve (12) gauge, cold formed, lipped channels designed to accept special, springheld, hardened steel nuts for securing hanger rods and other attachments. Two (2) or more such channels may be welded together forming horizontal members of greater strength than single channels. Members shall be Kindorf, Unistrut, or equal. Horizontal members made of Kindorf, Unistrut, or similar products shall be limited to a maximum length of eight (8) feet. Structural steel members shall be used for horizontal members exceeding eight (8) feet in length.
  2. Each multiple hanger shall be designed to support a load equal to the sum of the weights of the pipes, conduits, wire, and water, the weight of the hanger itself, and 200 pounds. The size of the hanger rods shall be such that the stress at the roof of the thread will not be over 10,000 pounds per square inch at the design load. No rod shall be smaller than 3/8 inch. The size of the horizontal members shall be such that the maximum stress will not be over 15,000 pounds per square inch at design load.
  3. Horizontal runs of piping and conduits along walls, four (4) inches and smaller, exposed or concealed, shall be secured to Kindorf or Unistrut support members as specified hereinbefore. Provide appropriate clamps, brackets and similar attachments to secure piping and conduits to vertical members in accordance with applicable sections of the specification.
  4. Refer to architectural and laboratory design drawings and specifications for additional requirements related to supports using Kindorf or Unistrut type systems.
- F. Hanger attachments shall be suitable for each type of hanger and shall be compatible with the building materials to which it is secured. The types of attachments which shall be used for the various types of building construction encountered shall conform to the following Anvil International figures:

1. Concrete (new) - Inserts Figs. 281 or 282. Power driven fasteners may be used for light loading as hereinafter specified.
  2. Concrete (existing) - Figs. 47, 49 or 52 attachments. Refer to drawings for specific application of individual types.
  3. Steel beams - Figs. 66, 92, and 93 attachments. Refer to drawings for specific application of individual types.
  4. Bar joists - Figs. 60 or 225.
  5. Brick or block walls - Figs. 194, 195, 199, or 202 fastened as follows: For light duty, self-drilling anchors in brick and toggle bolts in block; for heavy duty, through bolts with backing plates.
- G. Per IBC code section 1912 and ACI 318 Appendix D, all concrete anchors within the scope of ACI 318 require approved anchors for crack concrete. Attachment devices shall have certified load test data from an independent test laboratory and shall be capable of carrying a minimum of five times the design load. The concrete anchors for the following supported items need to meet the crack concrete requirements:
1. Any suspended pipe, larger than 2", regardless of material.
  2. All components with an Ip 1.5 (example) Sprinkler piping, gas lines, exhaust / fume hoods containing hazards.
  3. Cable tray.
  4. All components required to function after a seismic event (example) generator, emergency lightings, fire alarm and all associated conduits / panels, etc.
  5. Anywhere required by ASCE 7.
  6. All suspended HVAC and air distribution equipment, including air handling units, supply and exhaust air terminal units, fan coil units and fans.
- H. Welded attachments for securing hangers to piping or to structural steel may be provided in lieu of other attachments specified. Welded attachments shall be designed so that the fiber stress at any point in the weld or attachment will not exceed the fiber stress in the hanger rod.
- I. The different service pipes, valves, and fittings shall be installed so that, after the insulation/jacketing is applied, there shall not be less than 1 in. clear space between the finished jacketing and other work, and between the finished jacketing and parallel adjacent pipes.
- J. Refer to Division 23, Section "Mechanical Vibration, Sound and Seismic Controls", for vibration hanger requirements.
- K. In no case shall wire or perforated strap be used for pipe or conduit support.
- L. All piping, ductwork, and equipment shall be suspended from the structure above unless otherwise indicated or noted on the drawings. The Contractor shall obtain prior approval from the Architect for floor supports of piping, ductwork, and equipment. Provide structural steel members consisting of angles, channels, and beams as required to hang piping, ductwork, and equipment.
- M. Gripple hangers shall be used to suspend all exposed rectangular, oval, round and spiral ductwork. Gripple hangers shall consist of a pre-formed wire rope sling with either a pre-

formed ferruled loop, permanently fixed threaded stud, or permanently fixed end-stop with or without a toggle. This is secured and tensioned with a Gripple.

1. The contractor shall select the correct specification of Gripple hangers for supporting each particular service.
2. Gripple hangers shall be installed in accordance with all the manufacturer's recommendations.

#### 2.4 SLEEVES AND PLATES

- A. All pipe sleeves shall be constructed of one (1) piece Schedule 40 steel pipe, unless otherwise indicated on the drawings.
- B. Where watertight sleeves are indicated, provide Link Seal rubber seals, as manufactured by Thunderline Corporation, between pipes and sleeves.
- C. Escutcheon plates shall be provided for all exposed pipes passing through walls, floors, and ceilings in finished areas. Plates shall be chrome plated brass, split ring type, and sized to match the pipe or insulation where installed. Where plates are provided for pipes passing through sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.
- D. Provide twenty-four (24) gauge galvanized sheet metal sleeves for all exposed ductwork passing through floors, walls, or ceilings and all ductwork passing through fire-rated or smoke partitions. Duct sleeves shall be large enough to pass duct with insulation and shall have 2 (two) inch flanges returned against floor, wall, partition, or ceiling. Where fire dampers are required, provide sleeves as detailed on the drawings and as required by the damper manufacturer.
- E. At all sleeves, where noise can be transmitted and at fire rated separations, seal all openings between pipes and ducts and corresponding sleeve to prevent sound transmission and maintain fire rating of the wall, floor or ceiling. Submit method of sealing sleeves for approval. U.L. assembly rating of fire walls and floors shall be maintained at all times. All sleeves installed in masonry or concrete construction shall be grouted in place.

#### 2.5 FIRE RATED PENETRATION SYSTEMS

- A. Provide UL Listed fire penetration systems in openings in rated floors, walls, and other elements of construction. Provide UL listed fire penetration systems at all new and existing pipe penetrations of new and existing rated construction within the area of work. Coordinate work of this section with all other trades necessary for the proper installation of the fire rated penetration systems.
- B. Submit shop drawings showing each condition requiring penetration seals in dictating proposed UL systems materials, anchorage, methods of installation, and actual adjacent construction. Submit a copy of UL illustration of each proposed system indicating manufacturer approved modifications. Submit copies of manufacturer's specifications, recommendations, inspection

requirements, installation instructions, and maintenance data for each type of material required. Include letter indicating that each material complies with the requirements and is recommended for the applications shown.

- C. All fire penetration systems shall reference ASTM E814/UL 1479 - Fire Test of Through - Penetration Fire Stops.
- D. All systems shall be UL tested and listed in the UL Fire Resistance Directory.
- E. Submit copies of written guarantee agreeing to repair or replace joint sealers which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be one (1) year from date of substantial completion.
- F. 3M products have been specified as the penetration fire stop basis of design. Other manufacturer's systems are acceptable providing they meet the requirements set forth in this specification. The fire rated penetration systems shall be the products of one manufacturer to the maximum extent possible. The products of more than one manufacturer shall not be used as a combined seal.
- G. Provide materials classified by UL to provide fire stopping equal to time rating, both "F" and "T" ratings, of construction being penetrated. Provide asbestos free materials that comply with applicable codes and have been tested under positive pressure in accordance with UL 1479 or ASTM E814. Systems shall be smoke and air tight.
- H. Deliver material undamaged in manufacturer's clearly labeled, unopened containers identified with brand, type, grade, and UL label where applicable. Coordinate delivery with scheduled installation date to allow minimum storage time at site. Store material in clean, dry ventilated location. Protect from soiling, abuse, and moisture. Follow manufacturer's instruction.
- I. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.
- J. Furnish adequate ventilation if using solvent. Furnish forced air ventilation during installation if required by manufacturer. Keep flammable materials away from sparks or flame. Provide masking and drop cloths to prevent contamination of adjacent surfaces by fire stopping resistance.
- K. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose, materials, rust, or other substances that may affect proper fitting, adhesion of the required fire resistance.
- L. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instructions. Seal holes or voids made by penetrations to ensure an effective smoke barrier. Where floor openings without penetrating items are more than four (4) inches in width and subject to traffic or loading, install

fire stopping materials capable of supporting same loading as floor. Protect materials from damages on surfaces subject to traffic.

- M. Clean up spills of liquid components. Neatly cut and trim materials as required. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.
- N. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities. Perform under this section patching and repairing of fire stopping caused by cutting or penetration by local inspectors and other trades.

### PART 3 - EXECUTION

#### 3.1 WORKMANSHIP

- A. Each Subcontractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work.
- B. The quality of workmanship required, for each trade, in the execution of work shall be the finest and highest obtainable in that trade working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality is final.
- C. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

#### 3.2 EQUIPMENT PERFORMANCE

- A. All equipment, devices, controls, and hardware shall be proven to operate successfully throughout the guarantee period. Systems shall be proven during all weather seasons and be demonstrated to affect the design conditions at times. System components or equipments items that fail to consistently deliver the design conditions shall be removed and replaced as directed by the Architect. The cost of required equipment replacements shall be borne by the Contractor.
- B. All equipment shall be tested after installation and be proven to deliver the manufacturers quoted design capacity. When capacity is in question as deemed by the Architect, the Contractor shall perform a detailed and comprehensive field performance test to certify the equipment capacity. System effect or installed performance factors may not be applied to performance ratings unless they were previously included when the equipment was submitted for approval. Equipment that fails to deliver manufacturers quoted design capacity shall be removed and replaced at the Contractors expense.
- C. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.



### 3.3 EQUIPMENT CONNECTIONS

- A. All equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, piping specialties, water seals, valves, and electric connections recommended by the manufacturer, required by code or required for proper operation shall be provided.

### 3.4 WATERPROOFING

- A. Under no circumstances shall waterproofing be damaged or penetrated. Should conditions arise which indicate such necessity, notify the Architect.

### 3.5 CUTTING AND PATCHING

- A. Cutting and patching associated with the work in the existing structure shall be performed in a neat and workmanlike manner. Existing surfaces, which are damaged by the Contractor, shall be repaired or provided with new materials. All patching shall be done with materials and methods similar to existing adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary, non-percussive methods.
- B. The Contractor shall submit to the Architect for approval dimensioned drawings showing all penetrations through structural slabs or walls required for mechanical and electrical work. Drawings shall clearly show opening size, plan location, and/or elevation as applicable. All openings shall be approved by the Architect prior to starting work.
- C. Patching of areas disturbed by installation of new work shall match existing adjacent surfaces in material, texture, and color.

### 3.6 PROTECTION OF EXISTING WORK

- A. When working in and around the existing building, extreme care shall be exercised with regard to protection of the existing structure and mechanical and electrical services. Repair or replace, to the satisfaction of the Architect, any existing work damaged in the performance of the new work.

### 3.7 SURVEYS AND MEASUREMENTS

- A. Base all measurements (both horizontal and vertical) from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check correctness of same as related to the work. Verify locations of existing utilities and inverts of same prior to the start of any systems shown connecting to existing utilities.
- B. Should the Contractor discover any discrepancy between actual measurements or conditions, and those indicated, which prevent following good practice or the intent of the drawings and

specifications, he shall notify the Architect and shall not proceed with his work until he has received instruction from the Architect.

### 3.8 WELDING

- A. Welding shall conform to current standards and recommendations of the National Certified Pipe Welding Bureau, with all South Carolina Occupational Safety and Health Acts, State, City and County Fire Prevention Code Requirements, and NFPA Standard 241 including provision of appropriate portable fire extinguishers.
- B. Before assigning any welders to work covered by this specification, the Contractor shall provide the Architect with the names of pipe welders to be employed for the work, together with each welder's assigned number, letter, or symbol which shall be used to identify the work of that welder and which shall be affixed immediately upon completion of each weld. Contractor shall also submit, with the list of names, copies of each welder's certified qualification tests prescribed by the National Certified Welding Bureau or by other reputable testing laboratory using procedures covered in the American Society of Mechanical Engineers Building Construction Code, Section IX, "Qualification Standard Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators". Welders must be certified for all positions.
- C. If requested by the Architect, the Contractor shall submit identifying stenciled test coupons made by any welder in question. The Contractor shall require any welder to retake the tests when, in the opinion of the Architect, the work of the welder creates a reasonable doubt as to his proficiency. Tests, when required, shall be conducted at no additional expense to the Owner; and the welder in question shall not be permitted to work as a welder on this project until he has been recertified. Recertification of the welder shall be made to the Architect only after the welder has taken and passed the required test; welder must pass the test without benefit of retests in order to resume work as a welder on this project.
- D. Welding shall conform to the ANSI Code for Pressure Piping ANSI B31.9, Building Services Piping. The Contractor shall be responsible for the quality of welding and shall repair or replace any work not in accordance with these specifications. Contractor shall, without cost to the Owner, check welds by radiograph, ultrasonic testing, sectioning or a combination of these methods wherever there is a question raised by the Architect as to the quality of a weld. Examination of the questionable weld shall be in addition to other system tests specified. Welds shall have penetration complete to the inside diameter of the pipe. The recommended spacing and levels between ends of pipes prior to welding shall be used in all cases to assure full penetration.
- E. Welders on pressure piping shall be certified and carry their identification stamp with them. Welds on lines with operating pressures above 100 psig shall be stamped.

### 3.9 HANDLING AND STORAGE OF MATERIAL

- A. Proper and suitable tools, equipment and appliances for the safe and convenient handling and placing of all materials and equipment shall be used. During loading, unloading, and placing,

care shall be taken in handling the equipment and materials so that no equipment or materials are damaged.

- B. All mechanical and/or electrical equipment delivered to the job site shall be stored on pedestals, above the ground and under roof or other approved covering. All enclosures for equipment shall be weatherproof. All motors, drives, switchgear, panels, etc. which are not totally enclosed, that are involved in the work, shall be stored in a heated, dry, water protected area with a minimum temperature of fifty degrees (50) Fahrenheit. All valves shall be stored under roof on wood pedestals, above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.
- C. If any equipment and/or materials are found to be in poor condition at the time of installation the Architect may, at his discretion, order the Contractor to furnish and install new equipment and/or material at no cost to the Owner.

### 3.10 COOPERATION WITH OTHER TRADES

- A. Mechanical and Electrical trades shall give full cooperation to other trades and shall furnish in writing, with copies to Architect any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. Exact location of all mechanical and electrical equipment, devices, etc. in finished spaces shall be coordinated with Architectural reflected ceiling plans, elevations and details.

### 3.11 CLEANING AND PAINTING

- A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition ready for painting. Restore and touch-up factory finishes which have been damaged during construction. Finished painting will be performed under another Division.
- B. Miscellaneous requirements include:
  - 1. Touch-up threads of zinc coated screwed pipe with Rust-O-Leum primer and one (1) coat of enamel conforming with painting specification.
  - 2. Paint behind grilles and registers in finished areas with two (2) coats of flat black paint following the proper surface preparation of the zinc coated metal.

### 3.12 ACCESSIBILITY

- A. Locate all equipment which must be serviced, operated, or maintained, in fully accessible positions to eliminate the need for access panels and doors. Equipment shall include, but not be limited to, valves, clean-outs, motors, controllers, dampers, drain points, etc.

- B. Where overhead equipment cannot be located above spaces with either no ceilings or removable acoustical ceiling tiles, contractor shall provide, as part of the contract and no expense to the Owner, fourteen (14) gauge painted steel access doors where required and/or where directed (color shall match ceiling). Locations shall be coordinated with the Architect and indicated on the composite installation and coordination drawings.
- C. Access panels shall be Milcor or approved equal to suit material in which installed. Access doors installed in fire rated walls or shafts shall be labeled and shall match rating of the construction. Doors shall be of sufficient size to allow access to all components; minimum size shall be eighteen (18) inches by eighteen (18) inches. Doors in Toilet Rooms and Janitor's Closets shall be Type 304 stainless steel.
- D. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner. All doors shall have cylinder locks operable from same key. Submit shop drawings for approval.

### 3.13 EQUIPMENT BASES AND SUPPORTS

- A. Refer to Division 23, "Mechanical Vibration, Sound and Seismic Controls" for vibration isolation and seismic restraint requirements.
- B. Concrete bases, curbs, and supports will be furnished and installed under this Division and shall be in accordance with Division 3.
- C. The Subcontractors shall furnish, to the General Contractor, all required foundation sizes, bolts, washers, sleeves, plates and templates for equipment.
- D. The size of the foundation bolts shall be as recommended by the manufacturer.
- E. All equipment shall be set on the foundations, shimmed level with steel shims, and grouted up under base for uniform bearing by the Subcontractor.
- F. Under this Section, provide all equipment supports; consisting of inertia pads, platforms, gratings, structural members and related materials required for the mechanical and electrical work.
- G. The type and size of the supporting channels and supplementary steel shall be determined by the Subcontractor and shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.

### 3.14 SLEEVES AND PLATES

- A. Sleeves shall be provided by the trade installing the pipes or ducts for which sleeves are to be used. The sleeves shall be carefully located in advance of the construction of walls and floors, where new construction is involved. All cutting and patching necessary to set sleeves which are not placed prior to construction shall be the responsibility of the trade providing the sleeves.

- B. Sleeves shall be provided for all piping, conduits, and ducts passing through all floor slabs and concrete, masonry, tile, and gypsum wall construction.
- C. Fasten sleeves securely in floors and walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials from being forced into space between pipe and sleeve during construction.
- D. Where pipe motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of pipe. Where insulated pipes and ducts pass through sleeves, the sleeves shall be large enough to pass the pipe or duct and the insulation. Check floor and wall construction to determine proper length for various locations; make actual lengths to suit the following:
  - 1. Terminate sleeves flush with walls, partitions, and ceilings.
  - 2. Terminate sleeves two (2) inches above finished floors. Fill all voids between sleeves and structures with an approved sealant or grout as determined by the Architect. Refer to Architectural drawings and specifications for sealing requirements of sleeves in floor.
- E. Submit, for approval, shop drawings showing size, type, and location of all sleeves and penetrations through poured concrete walls or existing structure. Sleeves installed in load bearing concrete or masonry construction shall be completely grouted in place. See Architectural drawings for extent and location of such walls. Single and multiple pipe or conduit penetrations, as well as duct openings, shall be accurately located by field measurements and indicated on the drawings. The drawings shall be prepared sufficiently in advance for approval by the Architect and shall be prepared at a minimum scale of 1/8 inch equals one (1) foot.
- F. Structural members shall not be cut or penetrated. Notify the Architect where penetrations of structural members are required. Holes cut through concrete and/or masonry, to accommodate new work, shall be cut by reciprocating or rotary, non-percussive methods.

### 3.15 FLASHING

- A. Openings for pipes and ducts through waterproofed floors and roof areas shall be flashed. Vent pipes through roof shall be flashed with spun aluminum base having a minimum of five (5) inch roof surface flange. Base shall extend five (5) inches above roof surface.
- B. Fan bases shall be provided with prefabricated curbs as specified elsewhere in this Division.

### 3.16 DEMOLITION

- A. All existing piping, conduit, equipment, ductwork, and materials not required for re-use or re-installation shall be removed. Any existing materials and equipment which are removed and are desired by the Owner, or are indicated to remain the property of the Owner, shall be delivered to him on the premises by the Contractor where directed by the Architect. All other materials and

equipment which are removed shall become the property of the Contractor and shall be removed by him from the premises.

- B. Existing piping that remains concealed, buried, or otherwise contained in the remaining slabs and walls shall be capped, plugged, or otherwise sealed. All pipes shall be cut so that their capped or plugged ends will be below the finished floors or behind finished surfaces.
- C. Existing wiring, where possible, shall be removed or pulled through conduits. Wiring remaining shall be cut back behind the termination of conduits so that conduits can be adequately capped, plugged, or sealed.

### 3.17 CONNECTIONS AND ALTERATIONS TO EXISTING WORK

- A. When existing mechanical and electrical work is removed, all pipes, valves, ducts, and materials shall be removed to a point below the finished floors or behind finished walls and capped. Such points shall be far enough behind finished surfaces to allow for the installation of the normal thickness of finished material.
- B. When the work specified hereinafter connects to existing equipment, piping, or ductwork, the Contractor shall perform all necessary alterations, cuttings, or fitting of existing work as may be necessary or required to make satisfactory connections between the new and existing work and to leave the completed work in a finished and workmanlike condition, to the entire satisfaction of the Architect.
- C. When the work specified hereinafter or under other divisions of the contract necessitates relocation of existing equipment, piping, or ductwork, the Contractor shall perform all work and make all necessary changes to existing work as may be required to leave the completed work in a finished and workmanlike condition, to the satisfaction of the Architect. All work resulting in an extra to the contract shall be approved by the Owner and Architect before proceeding.
- D. All cutting and patching necessary for the installation of the mechanical work shall be done under this Division. Any damage done to the work already in place shall be repaired at the Contractor's expense. Patching shall be uniform in appearance and shall match the surrounding surface.

### 3.18 INTERRUPTION OF EXISTING UTILITIES

- A. Notify the Owner in writing at least seven (7) days in advance of any required shutdown of water, sewage, gas, electrical service or other utility. Upon written receipt of approval from Owner, shutdowns shall be performed between the hours of six (6) p.m. and six (6) a.m. including clean-up or as directed otherwise and shall be accomplished at no additional cost
- B. At the end of each interruption, all services shall be restored so that normal use of the building can continue.

END OF SECTION 230500

## SECTION 230530 – BASIC MATERIALS AND METHODS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

#### 1.2 SCOPE

- A. This section includes requirements for items of equipment, materials and procedures which are common to more than one section of Division 21, 22 and 23 and which are general in nature and use. This section applies to all sections of Divisions 21, 22 and 23.
- B. The requirements of Division 23, Section "Mechanical and Electrical General Provisions" shall apply to all work specified under this section.
- C. This section specifies the color schemes for painting exposed and insulated piping in the mechanical rooms. Refer to Division 9 for painting specifications.

#### 1.3 SHOP DRAWINGS

- A. Submit shop drawings for all items of materials specified in this section in accordance with the General Requirements.

#### 1.4 TESTS AND ADJUSTMENTS

- A. The Contractor shall furnish labor, instruments, equipment, and materials required to perform tests prescribed in the sections describing the various systems. All tests shall be performed in the presence of the Owner and/or the Architect. Forty-eight (48) hours prior notice shall be given to the Owner and Architect for all tests. A written test report shall be submitted following all tests and before systems are insulated.
- B. Replace or repair defects found during inspection or tests with new materials. Caulking of welded joints, screwed joints, cracks, or holes is not acceptable. Correct leaks in screwed fittings by remaking joints. Cut out and reweld. Repeat tests after defects have been eliminated.
- C. Where reasonable doubt exists as to a system's ability to comply with contract requirements,

perform any reasonable test required by the Architect.

- D. Make static pressure tests and prove to the satisfaction of the Architect the piping is tight before pipes are concealed. Tests shall be provided as hereinafter specified.
- E. Use test instruments tested for accuracy by an approved laboratory or by the instrument manufacturer, and furnish certificates showing degree of accuracy to the Architect when requested. Make calibration histories for each instrument available for examination.
- F. Where gauges, thermometers and other instruments which are to be left permanently installed are used for tests, do not install until just prior to the tests to avoid possible changes in calibration.

## 1.5 REFERENCES AND DEFINITIONS

- A. Unless otherwise specifically indicated, the term, and requirements of, "domestic" water systems shall universally apply to all potable, HVAC make-up and industrial laboratory water systems.

## PART 2 - PRODUCTS

### 2.1 HANGERS:

- A. See Division 23, Section "Mechanical and Electrical General Provisions" for general requirements.
- B. Hangers and accessories shall be Anvil International, Carpenter-Patterson, Michigan, B-Line, or Basic Engineering of the types specified in Division 23, Section "Mechanical and Electrical General Provisions".
- C. It shall be the responsibility of the Contractor to provide an adequate pipe suspension system in accordance with recognized engineering practices, using standard, commercially accepted pipe hangers and suspension equipment.
- D. The Contractor shall engage a qualified professional engineer to design an engineered pipe hanger and support system for all pipe systems of this Contract. Contractor shall perform calculations to ensure that the pipe support system being provided is adequate for the service. For all pipe hangers, supports, anchors, guides, etc., the Contractor shall submit a pipe hanger assembly drawing in accordance with the recommendations provided by MSS SP-89. Provide proposed equipment manufacturer, manufacturer's model number and size, construction, finish, quantities and/or lengths. Utilize columns shown on Contract Drawings for the location plan. Indicate pipe system, line size, insulation thickness, and Contract Drawing for which the plan view of the pipe hanger location can be found.
  - 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.

- E. All brackets used for supporting piping shall be provided by the Contractor and shall be of welded steel construction with a design safety factor of not less than five.
- F. The design of all hangers and supports shall conform to the latest requirements of ANSI/ASME B31.1 or ANSI/B31.9 and Manufacturers' Standardization Society (MSS) Standard Practice SP-58, SP-69 and SP-89, unless otherwise made more stringent below.
  - 1. Hangers for steel pipe, except as noted otherwise, shall be spaced at least every ten (10) feet.
  - 2. Hangers for cast iron pipe shall be provided at each joint.
  - 3. Hangers for copper pipe shall be placed at least every eight (8) feet, except pipes 3/4 inch and smaller shall have hangers at six (6) foot intervals.
  - 4. Plastic and polypropylene piping systems 1 1/4" and smaller shall be provided with continuous pipe support using light gauge sheetmetal angles strapped to pipes.
  - 5. Hangers shall be placed within one (1) foot of each horizontal and vertical elbow.
- G. Where concentrated loads of valves, fittings and similar items occur, closer hanger spacing will be necessary.
- H. Generally, hangers shall be clevis type, standard weight for lines 2-1/2 inch and larger.
- I. Vibration hangers shall be provided as hereinafter specified in Division 23, Section "Mechanical Vibration, Sound and Seismic Controls".
- J. Pipe Shields
  - 1. On insulated piping 2" and larger, provide Pipe Shields, Inc. Model No. A3000 and A5000 for use on warm systems and Model No. A4000 and A6000 for use on cold systems. Contractor shall select appropriate shield for support application.
  - 2. On insulated piping smaller than 2", provide insulation protection shield equal to Anvil International Figure 167. Shield shall comply with Manufacturers Standardization Society (MSS) SP-58 (Type 40).
- K. Hangers in direct contact with copper piping systems shall be copper plated.
- L. All hangers shall be prime painted for interior locations and galvanized coated for exterior locations.
- M. Hangers shall be provided with seismic restraints as required by IBC 2009 and ASCE 05-07.

## 2.2 IDENTIFICATION, VALVE TAGS AND CHARTS

- A. A complete identification system shall be provided for all mechanical and electrical components which conform to the requirements published in ASME A13.1, NFPA 13 and the Fuel Gas

Code.

- B. Product Data and Samples: In accordance with Division 1 Section "Submittal Procedures", submit the following:
1. Manufacturer's technical product data and installation instructions for each type of identification device specified. Include a list of all piping systems indicating a proposed nomenclature where a manufacturer's standard pre-printed nomenclature does not match up exactly with what is specified.
  2. Samples of each color, lettering style, and other graphic representation required for:
    - a. Brass valve identification tag.
    - b. Pipe contents and identification markers.
    - c. Valve Schedules: For each piping system. Reproduce on standard-size bond paper. Tabulate valve number, piping system, system abbreviation as shown on tag, room or space location of valve, and variations for identification. Mark valves intended for emergency shut-off and similar special uses. Besides mounted copies, furnish copies from maintenance manuals specified in Division 1.
    - d. Plastic equipment identification plates.
    - e. Paint colors for piping systems.
    - f. Stencils.
- C. All control devices, i.e.; panels, switches, starters, pushbutton stations, relays, temperature controls, etc., shall be clearly identified as to their function and the equipment controlled. All equipment such as pumps, fans, heaters, etc., shall be marked to clearly identify equipment and space or duty they serve. Mechanical equipment shall be identified using engraved laminated black and white phenolic legend plates. Letters shall be minimum 3/4 inch high white on surrounding black. Plates shall be mounted by means of sheet metal screws. Submit nameplate list for approval.
- D. Piping shall be identified with colored, prerolled, semirigid plastic labels as manufactured by Seton or approved equal. Labels shall be Seton "Set mark" system and shall be set around pipes with a field installed high strength cement compound applied along their longitudinal edge. Labels shall be placed around the piping or insulation every twenty (20) feet and with one (1) label on each pipe in rooms smaller than ten (10) feet. Provide labels on branch lines not more than 5 ft from main header. Provide labels on lines that penetrate walls or floors on each side of penetration not more than 5 ft from penetration. A label shall be placed at every major valve and at least six (6) feet from exit or entrance to an item of equipment. On exterior piping, utilize stencils to paint contrasting letters identifying pipe contents and direction of flow. Letter size and color shall comply with the requirements of adhesive pipe labels.
- E. For supply and exhaust air terminal units located above the ceiling, in addition to a label on the device, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the unit. Labels are to be black core white or beige Bakelite. The lettering is to be 3/8" inches high. The minimum label size is 3/4" wide by 1" long. Terminal units shall be identified as indicated on the mechanical drawings and ATC graphics. The thermostat that controls each air terminal unit shall be identified with an identical but appropriately sized label.

- F. For fire, smoke and fire/smoke dampers located above the ceiling, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the damper. Labels are to be black core white or beige Bakelite. The lettering is to be 3/8" inches high. The minimum label size is 3/4" wide by 1" long. Dampers shall be identified as "Fire Damper", "Smoke Damper" or "Fire/Smoke Damper".
- G. Labels shall have minimum 3/4 inch high black letters for pipes one (1) inch and larger, and 1/2 inch letters for smaller pipes. All labels shall have flow arrows. Color coding and stencil designations shall be as follows:

Service	Color	Stencil Designation
Potable Cold Water	Green	Potable Cold Water
Potable Hot Water	Green	Potable Hot Water
Potable Hot Water Recirc	Green	Potable Hot Water Recirc.
Sanitary	Brown	Sanitary Sewer
Steam	Orange	Steam (Designate Pressure)
Steam Condensate	Orange	Steam Condensate

- H. All valves, except as specified below, shall be provided with colored plastic valve tags with stamped-in numbers. Tags shall be secured to valve wheels with a metal chain. Stop valves on individual fixtures or equipment where their function is obvious, or where the fixture of equipment is immediately adjacent, need not be so equipped. Care shall be exercised in scheduling and selecting valve numbers to be indicated on a drawing. Drawing shall show locations, details of arrangements, identity, and function of all service and control valves. One (1) copy of each drawing and schedule shall be mounted and framed under plastic protection where directed. Blueprints are not acceptable. A copy of each drawing and schedule shall also be included as a part of the operations and maintenance manuals. Valve tags shall be Seton or approved equal minimum 1-1/2 inch round tags with white characters describing system and valve designation.
- I. Use color scheme indicated below for painting exposed and insulated piping in the mechanical rooms. Colors for piping not identified below shall be as indicated by Owner. Exterior non-insulated piping shall be painted with two coats of rust inhibitive paint. Colors shall be approved by the Owner after a sample is provided for each service. Do not paint aluminum jackets. Do not paint exposed copper or galvanized piping.

Service	Color
Potable Water	Green
Sanitary	Brown
Storm Water	Brown
Condensate Drain, Drain	Brown
Heating Water	Yellow
Steam	Orange
Steam Condensate	Orange

- J. Identify fire protection systems (sprinkler and fire alarm) as hereinafter specified as required by NFPA Standards

2.3 PIPE, FITTINGS AND JOINTS

- A. General: Items are referred to by type and shall conform to the latest editions of standards listed below:
- B. Provide pipe and fittings for fire protection as hereinafter specified in Division 21, Sections "Fire Protection."
- C. All piping shall be new domestic pipe material, manufactured in the United States of America (USA) and be suitable for the specific use indicated on drawings and in the specifications.
- D. Piping Material:

Service	Piping	Fittings	Joints
1. Sanitary drainage:			
a. Underground:	A	I	a
b. Above ground within building	J	VIII	i
c. Vent piping	J	VIII	i
2. Cold Water:			
a. Above ground - 4" and larger	F	III	e
b. Above ground - 3" and smaller	F	III	e
c. Underground - 3-1/2" and larger	K	IX	j
d. Underground - 3" and smaller	E	III	f
3. Domestic hot water, tempered water and hot water recirc:	F	III	e
4. Heating water supply and return:			
a. 2-1/2" and larger	C	VII	b
b. 2" and smaller	C	IV	c

- |    |                              |   |     |   |
|----|------------------------------|---|-----|---|
|    |                              | F | III | e |
|    | c. 2" and smaller (optional) |   |     |   |
| 5. | Steam and steam relief:      |   |     |   |
|    | a. 2-1/2" and larger         | C | VII | b |
|    | b. 2" and smaller            | C | XII | c |
| 6. | Steam Condensate:            |   |     |   |
|    | a. 2-1/2" and larger         | D | VII | b |
|    | b. 2" and smaller            | D | XII | c |

E. Piping Assembly:

Type	Designation
1. Cast iron hub and spigot pipe, service weight ASTM A74. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.	A
2. Copper drainage tubing, drain, waste, and vent, DWV, ASTM B306	B
3. Black steel pipe, ASTM A53/106 Grade B Seamless ANSI Schedule 40	C
4. Black steel pipe, ASTM A53/106 Grade B Seamless ANSI Schedule 80	D
5. Seamless copper water tube, ASTM B88, Type K, soft	E
6. Seamless copper water tube, ASTM B88, Type L, hard	F
7. Seamless copper water tube, ASTM B819 Type L, hard, prepared and labeled for oxygen service and sealed when delivered to the site	G

- |     |  |   |
|-----|--|---|
| 8.  | Corrugated and perforated black polyethylene drain pipe ASTM F-405 with three (3) rows of perforations and snap-lock ends  | H |
| 9.  | Cast iron soil pipe, service weight No-Hub, ASTM A-888. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.  | J |
| 10. | Ductile iron water pipe, outside coated, AWWA C104/A21.4 cement mortar-lined, ANSI/AWWA C151/A 21.51 pipe  | K |
| 11. | Black steel pipe ASTM A53/106 Grade B Seamless ANSI Schedule 40 with "X-Tru-Coat" Polyethylene or polypropylene coating (25 to 60 mils thickness)  | L |
| 12. | Galvanized steel pipe ASTM A53/106, Grade B seamless ANSI Schedule 40  | M |
| 13. | Enfield flame retardant polypropylene acid resistant drainage pipe, ASTM D635, Schedule 40   | N |
| 14. | Polypropylene (PP) pipe by George Fischer, Asahi, or Orion, equal to George Fischer PPro-Seal, suitable for use in reverse osmosis/deionized (RO/DI) water systems. Natural virgin copolymer polypropylene with no added plasticizers, pigments or re-grind that is manufactured to schedule 80 wall thickness and is compliant with US Food and Drug Administration regulations 21.CFR 177.1520 Sections A1, B & C and conforms to ASTM D4101. Pipe shall be manufactured to the dimensions and tolerances of ASTM D1785. All pipes shall be packaged in polybags at the point of manufacturing to preserve pipe cleanliness. | P |
| 15. | Plenumline FR-PVDF flame retardant polyvinylidene fluoride (PVDF) acid resistant drainage pipe, ASTM F 1673, Schedule 40, meeting the requirements of ASTM E84 and UL723   | Q |

F. Fitting Materials:

- | Type   | Designation |
|--|-------------|
| 1. Cast iron soil pipe fittings, service weight, ASTM A74      | I           |
| 2. Wrought copper and bronze drainage fittings, ANSI A16.29    | II          |
| 3. Wrought copper solder joint fittings, 150 pound ANSI B16.22 | III         |

- |     |   |      |
|-----|---|------|
| 4.  | Black malleable iron screwed fittings, 150 pound, ANSI B16.3 for less than seventy-five (75) pounds per square inch and 300 pounds for seventy-five (75) pounds per square inch or more   | IV   |
| 5.  | Black malleable iron grooved fittings, ASTM A47, Victaulic Style 07, Zero Flex. Galvanized fittings shall be used for domestic water.   | V    |
| 6.  | Corrugated polyethylene snap-lock drain fittings for snap-together assembly   | VI   |
| 7.  | Steel butt-welding fittings ANSI B16.9 using long-turn ells, ANSI B16.5 weld neck or slip on flanges & Bonney Forge Weldolets and Threadolets. Wall thickness to match pipe.  | VII  |
| 8.  | Cast iron soil pipe fittings, No Hub, ASTM A-888  | VIII |
| 9.  | Cast iron pressure fittings AWWA Class D, 250 pounds per square inch  | IX   |
| 10. | Steel butt-welding fittings ANSI B16.9 using long-turn ells with field applied "X-Tru-Coat" coating in accordance with manufacturer's recommendations   | X    |
| 11. | Galvanized malleable cast iron screwed fittings, ANSI B16.3, 150 pounds for less than seventy-five (75) pounds per square inch and 300 pounds for seventy five (75) pounds per square inch or more. Provide drainage fittings for drain pipe. | XI   |
| 12. | Black Cast iron screwed fittings, ANSI B16.4, 125 pound for less than seventy-five (75) pounds per square inch and 250 pounds for seventy-five (75) pounds per square inch or more  | XII  |
| 13. | Forged steel socket-welding fittings, ANSI B16.11, Class 3000, Schedule 40.   | XIII |
| 14. | Enfield mechanical joints and adapters. Connections containing EVA components are prohibited.   | XIV  |

XVI

15. Polypropylene (PP) fittings by George Fischer, Asahi, or Orion, equal to George Fischer PPro-Seal, suitable for use in reverse osmosis/deionized (RO/DI) water systems. Natural virgin copolymer polypropylene with no added plasticizers, pigments or re-grind that is manufactured to schedule 80 wall thickness and is compliant with US Food and Drug Administration regulations 21.CFR 177.1520 Sections A1, B & C and conforms to ASTM D4101. Pipe shall be manufactured to the dimensions and tolerances of ASTM D1785. All fittings shall be packaged in polybags at the point of manufacturing to preserve pipe cleanliness.

XVII

16. Plenumline acid waste fittings and adapters. Fittings shall be third party certified to ASTM F 1673 and ASTM E84, and IAPMO approved. Connections containing EVA components are prohibited, meeting the requirements of ASTM E84 and UL723

G. Joint Materials:

Type	Designation
1. Premolded rubber gaskets Tyler Pipe Industries, TY-Seal or Multiple Seal, ASTM C564	a
2. Welded: Mechanical Contractors Association of America, Inc. Guidelines for Quality Piping Installation (1995), Section 2.1.O	b
3. Threaded: American Standard for Pipe Threads, ANSI B2.1	c
4. Mechanical: Grooved pipe joints: Victaulic Style 07, Zero Flex. Roll grooving shall be prohibited	d
5. Soldered: ASTM B32 tin-antimony 95-5	e
6. Brazed: Silver alloy brazing equal to Silfos and Easy-Flo by Handy and Harman. The use of flux is prohibited	f
7. Brazed: Silver alloy brazing equal to Silfos and Easy-Flo by Handy and Harman. The use of flux is prohibited	g
8. Tongue and groove joint sealed with mortar	h



- 9. No-Hub neoprene gasket and stainless steel corrugated shield, Tyler No-Hub coupling i
  
- 10. Mechanical: Specification for Mechanical Joint or cast iron pressure pipe and fittings, ANSI A21.10 j
  
- 11. Enfield mechanical joints and adapters. Connections containing EVA components are prohibited. k
  
- 12. Butt-welded joint construction with an approved welding device, certified personnel and meeting the requirements of ASTM F1290/ASTM D2657 Section 9. All equipment should utilize electronically controlled heating elements for accurate welding temperatures. Tools should also incorporate planing units to face ends prior to heating. Butt-fusion equipment supplied shall weld joints based on force and/or pressure and not mechanical stops. m
  
- 13. Plenumline mechanical joints and adapters meeting the requirements of ASTM E84 and UL723, XVII. Connections containing EVA components are prohibited n

H. Pre-Insulated Direct Buried Piping System

- 1. Refer to Division 23, Section "Underground Distribution Piping".

2.4 VALVES

A. General:

- 1. Valves shall be provided where indicated on the drawings and as herein specified.
- 2. Valves shall be placed in such manner as to be easily accessible for hand wheel operation and stuffing maintenance.
- 3. Install shut-off valves in piping where shown or where listed below:
  - a. To isolate all items of equipment.
  - b. To isolate motorized flow control valves.
  - c. To isolate branch lines and riser at mains.
- 4. Valve pipe connections shall be screw, solder or weld flange as required to be consistent with other parts of the piping system.
- 5. Where piping or equipment may subsequently need to be removed, provide valves with bodies having integral flanges or full lugs drilled and tapped to hold valve in place so that downstream piping or equipment can be disconnected and replaced with blank-off plate while valve is still in service.
- 6. Valves over ten (10) feet above standing level and above six (6) inches in size shall have

chain wheel with chain extending to within six (6) feet of standing level. All wheel operated valves shall have an indicator to show the position of the disc or plug.

7. Where valves specified are not available in the pipe size noted on the drawing, the next larger size valve shall be provided.
8. Valves shall be provided for fire protection systems as specified in Division 21, Section "Fire Protection."

**B. Balancing Valves:**

1. Provide balancing valves where indicated and required to balance water flow through the piping system.
2. Balancing valves, 1 1/4 inches and larger, for systems piping shall be DeZurik as follows: PEC, flanged above two (2) inches with Buna filled PTFE U-ring seal and isobutene-isoprene plug facing, suitable for 250 degrees Fahrenheit continuous operation. Valves in chilled water and tower water systems may have seal and plug facing suitable for 180 degrees Fahrenheit. Valves six (6) inches and smaller shall have lever actuators and valves eight (8) inches and larger shall have gear operators. All actuators shall have adjustable memory stops.
3. Balancing valves one (1) inch and smaller shall be Armstrong Model CBV or as manufactured by TA Hydronics or approved equal.

**C. Butterfly Valves:**

1. Butterfly valves may be used in lieu of gate valves in chilled water, glycol water, condenser water and heating water systems size 2-1/2 inches and over.
2. Butterfly valves shall be Nibco, Centerline, DeZurik, Posi-Seal, or Jamesbury equal to Nibco Fig. No. 2000 lug body type, installed with welding neck companion flanges.
3. Valves shall have semi-steel or ductile iron lug body for flanged connection with alignment bolts, holes or guides, Type 416 stainless steel one (1) piece stem, upper and lower brass bushings, EPDM or nitrile (Buna-N) rubber liner, and aluminum bronze disc. Provide minimum two (2) inch extension neck on valves for insulated piping.
4. Pressure ratings shall be 150 pounds per square inch (psi) body; dead end bubble tight shut off for 200 pounds per square inch (psi) differential in either direction.
5. Actuators for valves six (6) inches and smaller shall be lever type with locking trigger with ten (10) position notched quadrant. Actuators on valves eight (8) inches and larger shall be heavy duty gear operators. All actuators shall have adjustable memory stops.
6. Butterfly valves shall not be used for steam, feedwater or condensate service.

**D. Ball Valves:**

1. Ball valves shall be used in all water systems size two (2) inches and smaller.
2. Ball valves shall be Nibco, Jamesbury, Apollo or Watts.
3. Two (2) piece ball valves sizes one (1) inch and smaller may be used for domestic water systems where replacement of internal parts is not critical. Valves shall be equal to Nibco Figure No. 585-70-66, bronze body, full port, stainless steel ball and stem (ASTM A-276, Type 316), TFE seat, blowout proof stem, extended stem for insulation thickness, and suitable for 150 pounds per square inch saturated steam service.
4. Three (3) piece ball valves sizes 1/2 inch to two (2) inch shall be used for all water piping systems to accommodate replacement of internal parts. Valves shall be equal to Nibco

Figure No. 595-Y-66, swing out design, bronze body, full port, stainless steel ball, and stainless steel stem (ASTM A-276 Type 316), reinforced TFE seats. Body bolts and nuts shall be zinc dichromate plated steel and valve shall be suitable for 150 pounds per square inch saturated steam service. Valves shall be threaded or soldered to suit piping systems which they are installed.

5. Three (3) piece ball valves sizes 1/2 inch to four (4) inch shall be used for all medical gas piping systems to accommodate replacement of internal parts. Valves shall be equal to Nibco Figure No. 595-Y-66, swing out design, bronze body, full port, stainless steel ball, and stainless steel stem (ASTM A-276 Type 316), reinforced TFE seats. Body bolts and nuts shall be zinc dichromate plated steel and valve shall be suitable for 150 pounds per square inch saturated steam service. Valves shall be threaded or soldered to suit piping systems which they are installed. All valves shall be serviceable in the line and supplied clean and prepared for oxygen service. Valves shall be packaged in a polyethylene bag to keep them clean on the job site.
6. Three (3) piece ball valves size 1/2 inch to two (2) inch shall be used for all steam and condensate piping systems to accommodate replacement of internal parts. Valves shall be equal to Nibco Figure No. 590-CS-R-66, stainless steel trim (A-276 type 316) with threaded or socket weld ends to suit system wherein installed.
7. Valves shall be equipped with lever handle with extended stem for insulation thickness which shall indicate position of ball orifice and have stops for fully open and closed position. Construction shall be such that power actuator can be used. Ball opening shall be full pipe size.
8. Valve shall be suitable for flow in either direction and must be leak proof at all pressures up to 150 pounds per square inch gauge (psig) and temperatures from minus twenty (-20) degrees Fahrenheit to 350 degrees Fahrenheit in open or shut position.

E. Drain Valves:

1. Drain valves shall be ball type as hereinbefore specified with hose end adapter and shall be provided at low points of all piping systems, and where indicated, 3/4 inch minimum.

F. Gas Valves:

1. Shut-off valves for natural gas service shall be ball type Jamesbury Clincher Type 2000 or approved equal for sizes up to two (2) inch. Valve shall have screwed ends, brass body, and 316 stainless steel trim. Valves shall meet UL Guide Designation YRPV for gas shut-off valves.
2. Shut-off valves for natural gas service shall be ball type Jamesbury Series 5150 ANSI Class 150 or approved equal for sizes greater than two (2) inches. Valve shall be flanged ends, ductile iron body, and 316 stainless steel trim. Valves shall meet UL Guide Designation YRPV for gas shut-off valves.

G. Valve Schedule:

1. Unless otherwise specified, valves shall be Nibco, Stockham, or Crane equal to the Nibco figure numbers indicated below:
  - a. Domestic Hot, Cold, Tempered and Recirculated Water Systems:

	Globe - Solder end	S-211-Y
	Check - Solder end	S-413-Y
	Gate - Flanged end	F-619
b.	Chilled Water, Glycol Water, and Condenser Water:	
	Gate - 2-1/2" and over	F-619
	Globe - 2-1/2" and over	F-718-B
	Globe - 2" and under	T-211-B
	Check - 2-1/2" and over	F-918-B
	Check - 2" and under	T-413-B
c.	Blowdown:	
	Quick Opening	Everlasting Series 4000 Meeting ASME/ANSI Code
d.	Steam Supply and Steam Condensate Return:	
	Gate - 2-1/2" and over	F-637-33
	Gate 2" and under	T-124
	Globe - 2-1/2" and over	F-768-B
	Globe - 2" and under	T-235-Y
e.	Condensate Return Only:	
	Check - 2-1/2" and over	F-918-B
	Check - 2" and under	T-413-B
f.	Heating Water:	
	Gate - 2-1/2" and over	F-619
	Globe 2-1/2" and over	F-718-B
	Globe - 2" and under	T-211-B
	Globe - Solder end	S-211-Y
	Check - 2-1/2" and over	F-918-B
	Check - 2" and under	T-413-B
	Check - Solder end	S-413-B
g.	Pumped Discharge:	
	Check - 2-1/2" and over	F-918-BL&W with lever and weight

## 2.5 PIPING SPECIALTIES

- A. Strainers shall be Mueller Steam Specialty Company, Inc., or approved equal, No. 351 for two (2) inch and smaller, No. 758 (125 lbs.) or No. 725 (250 lbs.) for 2-1/2 inch and larger. Basket strainers shall be Mueller Steam Specialty Company, Inc. or approved equal, No. 185. Provide valved blow-down connections on each strainer consisting of a ball valve set between two (2) short nipples. Blow-down valve shall be full size of strainer blow-down connection. Steam and condensate strainers shall be laid parallel to the floor to prevent the accumulation of condensate in the strainer body. Screens shall be stainless steel with perforations as follows:

Steam Service	3/64 inch perforations
---------------	------------------------

1. Contractor shall provide coarse construction strainers in each strainer or inline cone strainers in the piping system during equipment start-up periods. A list of construction strainers with their proposed location shall be submitted to the Architect for approval. After systems have been flushed clean and are fully operational construction strainers shall be removed and turned over to the Owner for accounting. Final strainer elements shall be installed after all construction strainers have been accounted for.

## 2.6 TEST PLUGS

- A. Pressure and temperature test plugs where indicated or required shall be 1/4 inch npt fittings, suitable to receive either a 1/8 inch outside diameter (OD) temperature or pressure probe. Fittings shall be solid brass with Nordel valve core, fitted with a color coded marked cap with gasket. The entire assembly shall be rated at 1000 pounds per square inch gauge (psig). Plugs shall be manufactured by Peterson Equipment Company, Inc., Richardson, Texas, or Sisco P/T plugs.

## 2.7 STEAM SYSTEM SPECIALTIES

- A. Steam System Strainers:

1. Provide Y Type strainers in compliance with Fluid Control Institute Standard 73-1, full size of connecting pipe. Provide integral blowdown connection.
2. Low & Medium Pressure Steam and Condensate Return:
  - a. Strainers shall be rated for 125 psig saturated steam.
  - b. Strainers 2 inches and larger shall be flanged, cast iron body. Strainers smaller than 2-inches shall be cast iron or bronze with screwed connections.
  - c. Strainer screens shall be type 304 stainless steel, free area not less than 2-1/2 times pipe area, with 20 mesh perforations.
  - d. Strainers shall be Spirax/Sarco type IT, CI-125 or F-125, or equal by Watts or Armstrong.
3. High Pressure Steam:

- a. Strainers shall be rated for 250 psig saturated steam.
- b. Strainers 2 inches and larger shall be flanged cast iron. Strainers smaller than 2-inches shall be cast iron, or bronze body with screwed connections.
- c. Strainer screens shall be type 304 stainless steel, free area not less than 2-1/2 times pipe area, with 20 mesh perforations.
- d. Strainers shall be Spirax / Sarco type IT, CI-250 or F-250, or equal by Watts or Armstrong.

**B. Steam Traps:**

1. Each type trap shall be the product of a single manufacturer. All trap bodies shall be constructed to permit ease of removal and service of working parts without disturbing connecting piping. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated on the drawings, traps shall be sized for capacities indicated at minimum pressure drop.
2. Steam Traps on Low Pressure Steam (15 psig and below):
  - a. Equipment or Process (with modulating control valve): Use Float and Thermostatic (F&T) type rated for 15 psi working pressure. Each trap shall be sized using 1 psi differential pressure at 2 times scheduled flow rate of equipment, based on a condensate leg of 18 inches at trap inlet and gravity flow to the main return line or receiver. Condensate may not be lifted to the return line unless otherwise approved by the Engineer. Traps shall be Spirax/Sarco UFT14 float & thermostatic steam trap with universal strainer connector with blowdown (parallel connection).
  - b. Main Line drips: Use balanced pressure thermostatic type rated for 15 psi working pressure. Main line drip traps shall be selected using 70 percent of design differential pressure at required flow. Provide trap sets at all low points and at 200 foot intervals on the horizontal main lines. Condensate may not be lifted to the return line unless otherwise approved by the Engineer. Traps shall be Spirax/Sarco UBP32 thermostatic steam trap with universal strainer connector with blowdown (bolt-on trap).
3. Steam Traps on Medium or High Pressure Steam (over 15 psig):
  - a. Equipment or Process (with modulating control valve): Use Float and Thermostatic (F&T) type rated for working pressure. Traps on equipment using 15 to 30 psig steam shall be sized for 3 times scheduled flow rate of equipment at 2 psig differential pressure. Traps on equipment using 30 psig steam and above shall be sized for 2 times scheduled flow rate of equipment at 5 psig differential pressure. Condensate may not be lifted to the return line unless otherwise approved by the Engineer. Traps shall be Spirax/Sarco UFT14 float & thermostatic steam trap with universal strainer connector with blowdown (parallel connection).
  - b. Main Line drips: Use Thermodynamic type on 15 psig and above. Traps shall be sized as indicated on plans. Main line drip traps shall be selected using 70 percent of design differential pressure. Provide drip trap sets at all low points and natural drainage points such as, ends of mains, bottoms of risers, and ahead of pressure regulators, control valves, isolation valves, expansion joints. On straight runs of

pipe with no natural drainage points, install drip legs at 200 foot intervals on the horizontal main lines. Condensate may be lifted to the return line. Traps shall be Spirax/Sarco UTD52L thermodynamic steam trap with universal strainer connector with blowdown (bolt-on trap).

4. Float and Thermostatic (F&T) traps shall comply with ASTM A126, cast iron body and bolted cover, with replaceable stainless steel float, lever and valve assembly. Thermostatic air vent shall be balanced pressure, stainless steel or bronze bellows with stainless steel valve and seat. Float and thermostatic trap shall not be installed in a manner to lift condensate up to a return line. F & T trap shall be Spirax/Sarco FT-15 to FT-200 or equal by Hoffman Specialty or Armstrong.
  5. Balanced pressure traps shall be maintenance-free and tamper-proof design of all stainless steel construction with forged body and drawn cover completely sealed against leakage. Operating element to be a solidly liquid-filled thermostatic capsule which self adjusts to all pressures to 435 psig. Trap shall vent air freely and withstand waterhammer, freezing and superheat. Balanced pressure trap shall be Spirax/Sarco BP32 or equal by Hoffman Specialty or Armstrong.
  6. Thermodynamic traps with integral strainers shall be stainless steel body, disc, insulating cap and integral strainer with blowdown connection, rated for 600 psig. Trap shall be Spirax/Sarco TD42L or equal by Hoffman Specialty or Armstrong.
  7. Universal connector (bolt-on) steam traps shall consist of stainless steel pipeline connector with integral strainer & blowdown which when installed remains in the line permanently. Stainless steel trap shall be attached to the connector by two bolts to enable simple and rapid installation and replacement. Bolting pattern on connector shall be universal among manufacturers and shall be capable of accepting thermodynamic, balanced pressure thermostatic, inverted bucket, or float & thermostatic steam traps. Universal traps shall be Spirax Sarco UTD52, UBP32, UFT14 or equal.
- C. Combination Vacuum Breaker/Air Vent: Cast iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 125 psig working pressure, 1/2-inch screwed connections. Vacuum breaker shall be stainless steel construction, including the body, threaded cap, valve and valve seat. Air vent shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure. Combination vacuum breaker/balanced pressure thermostatic air vent shall be Spirax/Sarco VB-VS, or equal by Watson-McDaniel or Armstrong.
- D. Unions, Flanges and Couplings
1. Use unions for pipe 2 inches and smaller. 150 psig galvanized malleable iron, threaded.
  2. Use flanges for pipe 2 1/2" inches and larger. 150 psig forged steel, slip on.
  3. Gaskets: 1/16 inch thick, non-asbestos graphite fiber.
  4. Dielectric connections shall be union with galvanized or plated steel threaded end, copper solder and, water impervious isolation barrier.
- E. Steam pressure regulating valves shall be Spence Regulator Type ED or approved equal. Regulators shall have the capacity as indicated on the drawings.
- F. Relief valves for steam systems sizes two (2) inches and less shall be Spirax Sarco, ASME Standard 6000 Series or approved equal. Relief valves for steam systems sizes 2.5 inches and

larger shall be Lonergan, ASME Standard D Series or approved equal.

- G. Noise suppressor for steam pressure reducing stations shall be Spence ANSI Class 150 with welded steel components, stainless steel acoustic material, and 500 degrees Fahrenheit temperature rating. Suppressor shall have 150 pound flat faced flanges and drain connection in bottom.
- H. Flash tank shall be Spirax Sarco flash recovery vessels or approved equal, ASME Stamped and approved. Tank capacity and size shall be as indicated on the drawings.

## 2.8 DIELECTRIC FITTINGS

- A. General: Provide assembly or fitting with insulating material isolating joining of dissimilar metals, to prevent galvanic action and stop corrosion.
- B. Description: Combination of copper alloy and ferrous; threaded, soldered, plain end, or weld neck types matching piping system materials.
- C. Insulating Material: Suitable for system fluid, pressure, and temperature.
- D. Dielectric Unions: Factory-fabricated, union assembly, for 250 psig minimum working pressure at 180 deg. F.
- E. Dielectric Flange Insulating Kits: Field assembled, companion flange assembly, full face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers. Provide Class 150 or Class 300 flanges to match system pipe requirements.
- F. Dielectric Couplings: Galvanized steel coupling with inert and non-corrosive, thermoplastic lining, threaded with 300 psig minimum working pressure at 225 deg. F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining, threaded with 300 psig minimum working pressure at 225 deg. F.

## 2.9 FLEXIBLE CONNECTORS

- A. General: Provide stainless steel braided flexible connectors with design pressure and temperature rating meeting or exceeding the test pressures and operating temperatures of the systems in which they are installed. Pipe sizes 2-inch and smaller shall be socket welded or threaded matching system requirements. Pipe sizes above 2-inch shall be Class 150 or Class 300 flanged matching system requirements.
- B. Stainless steel hose / Steel pipe, flexible connectors: Corrugated, stainless steel inner tubing covered with stainless steel single wire braid. Include steel nipples or steel flanges welded to hose. Minimum length shall be three times pipe diameter up to 4-inch pipe size and two times pipe diameter up to 18-inch pipe size.



## 2.10 PIPE ANCHORS

- A. All pipe lines shall be anchored where specified herein, indicated on drawings and where required to prevent uncontrolled movement. Anchors shall be constructed of steel sections and plates, assembled by bolting or welding and secured to the building structure by means of bolts, clamps or welding. Anchors shall prevent both axial and lateral movement of the lines. Anchor vertical pipes by means of clamps welded to pipe and secured to wall or floor construction. Submit details of anchors for approval.
- B. Anchor piping adjacent to flexible pipe connectors to prevent connector from expanding against its restraining bolts and also to keep the pipe on both sides of the connector in alignment.

## 2.11 EXPANSION

- A. All piping shall be so installed that it will in no way be distorted or strained by expansion or contraction. Except as noted, all expansion and contraction shall be taken up by means of swing joints, loops, bends or long offsets. Swing joints made up with at least three (3) elbows shall be provided in branches from mains in runouts. Size loops for the total pipe expansion without cold springing, but field cold spring 1/2 the pipe on expansion corrected for ambient temperature.
- B. Where expansion joints are indicated or required, select joints with a traverse of 150 percent of the pipe expansion from an ambient of forty (40) degrees Fahrenheit to the maximum system operating temperature.
- C. Expansion joints two (2) inches and larger shall have flanged ends, except when installed in copper piping systems.
- D. All expansion joints shall be suitable for minimum operating pressure and temperature of 150 pounds per square inch (psi) and 300 degrees Fahrenheit respectively.
- E. Expansion joints shall be of the following types:
  - 1. Corrugated Type - Flexonics "Low-Corr" joints for pipes three (3) inches and larger. Flexonics Model H or HB for pipes smaller than three (3) inches.
  - 2. Slip Type - Flexonics "Slip Pakt" with anchor base.
- F. Submit, for approval, manufacturers' shop drawings of each expansion joint provided depicting length of pipe, location of anchors and guides, calculated expansion offset and type of joint employed.

## 2.12 PIPE GUIDES

- A. Install pipe guides where indicated on drawings or where required for proper installation of expansion loop. Limit use of guides with expansion loop to points shown or where required to prevent buckling of pipe whether indicated or not.

- B. Do not use pipe guides as pipe supports.
- C. Provide factory made cast semi-steel or other heavy fabricated steel consisting of a bolted two (2)-section outer cylinder and base with a two (2)-section guiding spider welded or bolted tight to the pipe, of sufficient size to clear pipe insulation and long enough to prevent over-travel of spider in cylinder. Furnish a guide sleeve of a length not less than the length of pipe expansion plus the spider length.
- D. When installed in cooling systems, guides must permit the application of thermal insulation.

#### 2.13 MISCELLANEOUS MATERIALS FOR SUPPORTS, HANGERS, ANCHORS AND GUIDES

- A. The Contractor shall provide all miscellaneous materials required to properly install all supports, hangers, anchors and guides, including:
  - 1. Steel Plates, Shapes and Bars: Provide products complying with ASTM A36.
  - 2. Cement Grout: Portland Cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
  - 3. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

### PART 3 - EXECUTION

#### 3.1 CLEANING, FLUSHING, INSPECTING

- A. General: Clean exterior surfaces of piping systems of superfluous materials, and prepare for application of specified coatings (if any.) Clean interior of pipe by mechanical means to remove welding slag, metal filings, dirt, and debris. Flush out piping systems to the satisfaction of the Owner before proceeding with required tests. Inspect each run of each system for completion of joints, supports, and accessory items.
  - 1. Inspect Power Piping in accordance with procedures of ASME B31.1.
- B. The Contractor shall submit a detailed pipe flushing plan detailing the efforts to be taken to ensure a completely clean piping system. Any damage to existing or new equipment or components shall be repaired or replaced at the Contractor's expense to the satisfaction of the Owner.
- C. The Contractor shall clean and flush all installed piping systems with a clean water solution with additives formulated to assist in the removal of welding slag, metal filings, oil, and grease. Flushing operations shall maintain a minimum velocity of six feet per second for a minimum four hour time frame. Repeat flushing operations to the satisfaction of the Owner and until flushing water is completely clear. System pumps may be utilized for flushing operations with fine mesh start-up screens. Clean screens often and replace with final system screens at

completion of flushing operations. Provide temporary equipment bypasses for all components where metal slag and filings are prone to collect (such as chillers, heat exchangers, and boilers.) The Contractor shall provide all temporary equipment and piping necessary to complete the flushing operations. Cooling tower basins shall be drained, cleaned of all mud and dirt, and sump screens cleaned. Cooling tower basins shall be checked and reflashed weekly during site construction activities that create airborne dust and particles.

- D. Refill and vent water systems being sure to add water after venting to completely fill system.
- E. Disinfect new or repaired water mains and water service piping in accordance with AWWA A601 and section 610 of the 2006 International Plumbing Code.
- F. Provide water treatment services as indicated in other Division 23 specification Sections.

### 3.2 PIPING INSTALLATION

- A. Install piping without undue stress or strain in locations shown and run parallel to the lines of the building, except to grade them as specified in neat and workmanlike manner using a minimum of fittings. Provide such fittings, valves and accessories as may be required to meet the conditions of installation. Contractor shall inform himself fully regarding any peculiarities and limitations of space available for installation of material under each section of specifications. Install piping to suit necessities of clearance with ducts, conduits, and other work, and so as not to interfere with any passages or doorways and allow sufficient head room at all places. Use proper reducing fittings for changing piping sizes.
- B. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing. Perform cutting by means of an approved type of mechanical cutter of the wheel type where practicable. Ream pipe after cutting to remove all burrs.
- C. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories that may be required. Carefully investigate the architectural and structural conditions affecting the work, and arrange such work accordingly, providing such fittings, and accessories as may be required to meet such conditions. Drawings (plans, schematics, and diagrams) indicate the general location arrangement and restrictions of the piping systems. Location and arrangement of piping layout shall take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated on the Contract Drawings unless deviations to layout are approved on the Coordination Drawings. The Contract Drawings are diagrammatic in nature and are not welding fit-up documents. The Contractor is responsible for a complete installation. Refer to individual system specifications for requirements for coordination drawing submittals.
- D. Install at low points of gas piping and at the foot of each riser and each drip, a "T" fitting and six (6) inch long capped drip pocket of same size and riser or drip. Grade horizontal gas pipe to prevent traps. Pipe all green gas vents to the exterior as required by Code. Make all joints with graphite and oil and in accordance with National Fuel Gas Code requirements.
- E. Install unions and flanges where shown and on each side of all pieces of equipment and other

similar items, and in such a manner that the unions can be readily disconnected. Do not place any union or flange in a location which will be inaccessible after completion of the project unless so shown on drawings or specified.

1. Unions in steel pipe 2 1/2 inches and smaller, shall be 250 pound malleable iron, brass seat type. Use 150 pound forged steel flanges for piping three (3) inches and larger. Gaskets shall be 1/8 inch thick.
  2. Unions in copper pipe two (2) inches and smaller shall be wrought copper with red bronze ring nut. Use 150 pound ASME copper flanges for piping 2 1/2 inches and larger. Use dielectric unions or couplings where nonferrous metal is joined to ferrous metal.
- F. Use reducing fittings, eccentric where required to prevent pocketing of air and water or both, to make changes to pipe sizes.
- G. HVAC piping shall be installed plumb, level, and square with low point drains and high point vents. Steam, condensate, drain and sanitary waste and vent piping shall be sloped per code.
- H. Contractor shall fully coordinate the installation of all piping systems with all other trades including sheet metal, electrical, sprinkler, ceiling systems, etc.

### 3.3 JOINTS

#### A. Steel Pipe Joints:

1. Threaded Pipe Joints, 2" and Smaller: Thread pipe with tapered pipe threads in accordance with ANSI B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed. Align threads at point of assembly. Tighten joint with wrench. Do not use pipe or pipe fittings with threads that are damaged or corroded. Do not use pipe sections that have cracked or open welds. Comply with the provided pipe material classification requirements for allowance of threaded pipe within each service type. Threaded pipe will not be allowed for high temperature hot water service.
2. Pipe Larger Than 2":
  - a. Weld pipe joints in accordance with ASME Code for Building Services Piping, 31.9. Bevel weld end to end. Sleeve welds shall not be permitted.
  - b. Install flanges on all valves, apparatus, and equipment. Weld pipe flanges to pipe ends in accordance with ASME Code for Building Services Piping. Clean flange faces and install gaskets. Tighten bolts gradually and uniformly using a torque wrench to torque specified by manufacturer or flange and sequence flange bolts, to provide uniform compression of gaskets. Use suitable lubricants on bolt threads.

#### B. Non-Ferrous Pipe Joints:

1. Brazed and Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ANSI B31.31.0 – Standard Code for Pressure Piping, Power Piping and ANSI B9.1

- Standard Safety Code for Mechanical Refrigeration.
  - 2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emory cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
- C. Weld pipe joints in accordance with ASME Code for Building Services Piping, B31.9. Weld piping in accordance with recognized industry practice and as follows:
- 1. Weld pipe joints only when ambient temperature is above 0 degree F.
  - 2. Bevel pipe ends at a 37.5 degree angle, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
  - 3. Use pipe clamps or tack-weld joints with 1" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".
  - 4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
  - 5. Do not weld out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.
- D. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.
- E. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions.

### 3.4 WORKMANSHIP

- A. Cut pipes accurately to measurements established at structure. Install pipes without springing or forcing.
- B. Clear windows, doors, and other openings with all pipes and ductwork.
- C. Arrange pipes to permit expansion and contractions without misalignment or damage.
- D. During construction all openings in piping and equipment shall be closed with caps or plugs to keep out all foreign matter and to prevent leakage.
- E. All piping in finished spaces shall be run concealed unless otherwise indicated.

### 3.5 WELDING

- A. Refer to Division 23, Section "Mechanical and Electrical General Provisions".

### 3.6 SLEEVES AND PLATES

- A. Sleeves shall be provided by the trade installing the pipes for which sleeves are to be used. The sleeves shall be carefully located in advance of the construction of walls and floors where new construction is involved. All cutting and patching necessary to set sleeves which are not placed prior to construction shall be the responsibility of the trade providing the sleeves.
- B. Sleeves shall be provided for all piping passing through all floor slabs and concrete, plaster, gypsum, or masonry wall construction.
- C. Where pipe motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of pipe. Where sleeves pass insulated pipes, the sleeves shall be large enough to pass the pipe and the insulation. Check floor and wall construction to determine proper length for various locations; make actual lengths to suit the following:
  - 1. Terminate sleeves flush with wall.
  - 2. Terminate sleeves two (2) inches above finished floors.
- D. Submit for approval shop drawings showing size, type, and location of all sleeves and penetrations through poured concrete walls. See Architectural Drawings for extent and location of such walls.
- E. All pipe sleeves shall be constructed of Schedule 40 steel pipe unless otherwise indicated on the drawings.
- F. See drawings for additional sleeve requirements.
- G. Fasten sleeves securely in floors and walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials from being forced into space between pipe and sleeve during construction. Caulk the annular space with elastic caulk compound or as noted to make tight.
- H. Where watertight sleeves are indicated, provide Link Seal rubber seals, as manufactured by Thunderline Corporation, between pipes and sleeves, or provide sleeves as detailed.

### 3.7 STEAM SYSTEMS

- A. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves require eccentric reducers to connect to pipe sizes shown on the drawing.
- B. Provide full line size strainers as indicated and ahead of all steam traps, pressure regulating/reducing valves, and temperature control/regulating valves unless integral strainer is provided. Provide each strainer with a valved blow-off, full size of blow-off connection. Strainers installed in steam piping systems shall be oriented in the side position.
- C. Install steam traps with union or flanged connection on both ends of trap with shut-off valves,

inlet strainer and outlet check valve. Install steam traps in accessible locations as close as possible to connected equipment, but not more than 48" from equipment. Provide dirt leg with blow down as recommended by manufacturer. Install drip traps close to drip leg. Sized drip legs at vertical risers same size as pipe and extend beyond rise. Size drip legs at other locations same diameter as main, up to 5". In steam mains 6" and larger, dirt leg size can be reduced, but in no case less than 4" NPS.

- D. Install steam pressure gauges with siphons and isolation valves both upstream and downstream of pressure reducing valves, heat exchangers, condensate return pumps, and at other locations indicated on the drawings.
- E. Install premanufactured accessories and equipment in accordance with the manufacturer's instructions and recommendations.

### 3.8 TESTS

- A. The following tests shall be conducted by the Contractor and all piping shall be proven tight in the presence of the Architect or his representative. These tests shall be conducted before any insulation is installed and any insulation installed prior to tests shall be removed. Provide all equipment and labor required. Tests shall be at least four (4) hours in duration, after all piping has been proven tight. Piping may be tested in sections as approved by the Architect. Tests shall be as specified herein and a written test report shall be submitted to the Architect within two (2) days following each individual test. All test reports shall be included in the operation and maintenance manuals.
- B. The domestic water piping shall be hydrostatically tested to 150 pounds per square inch gauge (psig). All openings in the water piping shall be plugged; the system, or portion thereof, filled with water, and tested with a pump to a pressure of 150 pounds per square inch gauge (psig). Domestic water system piping shall be disinfected after tests in accordance with Baltimore City and Maryland State Health Department Requirements.
- C. The sanitary and miscellaneous drain systems shall be hydrostatically tested. Tests shall be as required by code and as a minimum shall comprise of the plugging of all openings in the lines, filling the system (or portion thereof), with water until all joints are proven tight. Piping shall be tested with a minimum head of ten (10) feet of water.
- D. All heating water, chilled water, glycol water, condenser water, and steam piping shall be hydrostatically tested to 1-1/2 times the system working pressure or a minimum of 100 pounds per square inch gauge (psig), whichever is greater.
  - 1. Underground piping systems shall be hydrostatically tested before insulation is applied at field joints, and shall be proved tight at a pressure of 1-1/2 times the working pressure, but not less than 150 pounds per square inch gauge (psig). Duration of test shall be four (4) hours, with no leakage.

### 3.9 STERILIZATION

- A. Domestic water system piping shall be disinfected in accordance with State of South Carolina Health Department requirements and Section 610 of the 2006 International Plumbing Code. A written test report shall be submitted to the Owner and Architect within five (5) days following the sterilization process and before occupancy is granted. All written reports shall be included in the operation and maintenance manuals.
- B. After final testing for leaks, all new domestic water lines shall be thoroughly flushed by Contractor to remove foreign material. Before placing the systems in service, Contractor shall engage a qualified water service Contractor to sterilize the new water lines. Sterilization shall include as a minimum the following procedure:
  - 1. Through a 3/4" hose connection in the main entering the building, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 parts per million. The Contractor shall provide plumbing connections and power for pumping chlorine into the system.
  - 2. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.
  - 3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 parts per million chlorine, retain this water in the system for three (3) hours. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system which shall be replaced by the Contractor at no additional cost.
  - 4. At the end of the retention period, no less than 100 parts per million of chlorine shall be present at the extreme end of the system.
  - 5. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 parts per million.
  - 6. Obtain representative water samples, at least two (2), from the system for analysis by a recognized bacteriological laboratory.
  - 7. If the samples tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the water service organization to the Contractor, certifying successful completion of the sterilization.
  - 8. If any samples tested indicate the presence of coliform organism, the entire sterilization procedure shall be repeated.

### 3.10 MOLD AND CONDENSATION PREVENTION

- A. Piping Systems: Cold piping systems (such as cold water) shall not be operated prior to insulation and vapor barrier installation in order to prevent condensation on the piping.
- B. Air Systems: Air handling systems shall not be operated at supply air temperatures below fifty (50) degrees F and all supply air ductwork shall be insulated prior to operation. Coils shall be insulated to prevent condensation when heating valve is closed. Air systems shall not be operated in portions of the building not yet fully enclosed, where systems can be exposed to warm, humid air conditions.
- C. Room thermostats shall not be set lower than sixty-eight (68) degrees F. Programmable



thermostats shall be set to prevent lower temperature setting from the exterior of the thermostat by room occupants.

- D. Contractor shall notify the Architect immediately if signs of condensation or mold are discovered.

END OF SECTION 230530

## SECTION 230548 - MECHANICAL VIBRATION, SOUND AND SEISMIC CONTROLS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.
- B. The 2009 International Building Code and SEI/ASCE 7-05 Standard apply to all work associated with the seismic installation of all new mechanical and electrical equipment. Refer to Architectural and Structural drawings for seismic loads and additional seismic information.

#### 1.2 SCOPE

- A. This section includes requirements for items of equipment, materials and procedures which are common to more than one section of Division 22 and 23. This section applies to all sections of Divisions 22 and 23.

#### 1.3 SUMMARY

- A. This Section includes the following:
  - 1. Elastomeric hangers.
  - 2. Spring hangers.
  - 3. Spring hangers with vertical-limit stops.
  - 4. Thrust limits.
  - 5. Pipe riser resilient supports.
  - 6. Resilient pipe guides.
  - 7. Restraining cables.
  - 8. Certification of seismic restraint designs and installation supervision.
  - 9. Certification of seismic attachment of housekeeping pads.
- B. Work includes vibration control devices, materials, and related items for mechanical and electrical systems. Perform all work as shown on the drawings and as specified herein to provide complete vibration isolation systems in proper working order.
- C. The requirements of Division 15, Section "Mechanical and Electrical General Provisions" shall apply to work specified under this section.

#### 1.4 DEFINITIONS

- A.  $A_v$ : Effective peak velocity related acceleration coefficient.
- B. OSHPD: Office of Statewide Health Planning & Development for the State of California. OSHPD assigns a unique anchorage preapproval "R" number to each seismic restraint it tests. The number describes a specific device applied as tested.
- C. Life Safety Systems:
  - 1. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.
  - 2. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flowpaths to fire protection and/or emergency lighting systems.
  - 3. All medical and life support systems.
  - 4. Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.
  - 5. All life safety equipment has an asterisk on the equipment schedule.
- D. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, or any other equipment are not acceptable on this project as seismic anchor points.
- E. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.
- F. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.
- G. Failure: For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8" and/or horizontal permanent deformation greater than 1/4".

#### 1.5 SUBMITTALS

- A. Product Data: Include load deflection curves for each vibration isolation device.
- B. Shop Drawings: Signed and sealed by the manufacturer's qualified professional engineer. Before ordering any products, submit shop drawings of the items listed below. The shop drawings must be complete when submitted, be based on equipment actually purchased and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal. Include the following:

1. Product Description: A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
  2. Selection Data: Detailed selection data for each vibration isolator supporting equipment, including:
    - a. Equipment identification mark;
    - b. Isolator type;
    - c. Actual load;
    - d. Static deflection expected under the actual load
    - e. Specified minimum static deflection.
  3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases. Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by the manufacturer's registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
  4. 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.
  5. Vibration Isolation Base Details: Detail 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.
  6. 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.
  7. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.
  8. Seismic restraint calculations.
  9. Provide Approved Agencies Certificate of Compliance meeting Seismic Category D for all components. Tests shall include anchorage, structural and on line capability from analytical or shaker test method.
- C. Submission of samples may be requested for each type of vibration isolation device. After approval, samples will be returned for installation at the job if requested. All costs associated with submission of samples shall be borne by the Contractor.
- D. Welding certificates.
- E. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

## 1.6 MANUFACTURER RESPONSIBILITIES

- A. Manufacturer of vibration isolation and seismic restraint equipment shall have the following responsibilities:
  1. Determine vibration isolation and seismic restraint sizes and locations.
  2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.
  3. Guarantee specified isolation system deflection.
  4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
  5. Provide certification by a licensed engineer employed by the manufacturer that all mounts and restraints meet the project requirements for seismic loading.
- B. Substitution of internally isolated mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above acceleration loads are certified in writing by the equipment manufacturer and stamped and sealed by a licensed civil or structural engineer.

## 1.7 RELATED WORK

- A. Supplementary Steel
  1. Provide any incidental materials and supplementary support steel for all equipment, piping, ductwork, roof mounted equipment, etc., such as mounting brackets, attachments and other accessories, that may be needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, at no additional cost.
- B. Attachments
  1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

## 1.8 QUALITY ASSURANCE

- A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage preapproval "R" number, from OSHPD or

another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.

- B. Seismic restraints for mechanical systems shall comply with 2009 IBC and ASCE 7-05.
- C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."
- D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.
- E. Should any rotating or electrical equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.
- F. Upon completion of the work, the Architect shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.
- G. The contractor shall provide a quality assurance plan prepared by a registered design professional for all mechanical, plumbing and electrical equipment and systems. The plan shall include the provisions of the 2009 International Building Code, per section 1705.2 and 1705.3. The plan shall be submitted to the Architect for review and approval. The contractor shall coordinate the requirements of the plan with the Owner and shall cooperate with the Owner's Seismic Quality Assurance coordinator.

#### 1.9 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

#### 1.10 EXTRA MATERIALS

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

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

### 2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers:

1. Amber/Booth Company, Inc.
2. B-Line Systems, Inc.
3. California Dynamics Corp.
4. Kinetics Noise Control, Inc.
5. Loos & Co., Inc.; Cableware Technology Division.
6. Mason Industries, Inc.
7. TOLCO Incorporated.
8. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
9. Vibration Eliminator Co., Inc.
10. Vibration Isolation Co., Inc.
11. Vibration Mountings & Controls/Korfund.

B. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 40, plus or minus 5, with a flat washer face.

C. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 40, plus or minus 5.

D. 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.

E. 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.

F. General Requirements:

1. Equipment, piping, ductwork and conduit shall be braced and supported in accordance with International Building Code, 2009 - Chapter 16.
2. This Contractor shall provide the services of a professionally registered Seismic consultant to perform duties indicated below. The Contractor shall submit with his bid, the hourly billing rate for their Seismic consultant to provide additional services beyond the specified scope..

G. Mechanical Equipment:

1. All equipment bases and mounting tabs shall be provided integral to the equipment and designed to distribute Seismic loads without failure. Equipment bases mounting tabs shall be certified by the manufacturer to be in accordance with the requirements of this specification.
2. The size, type and quantity of anchors and fasteners required to anchor the equipment will be provided in accordance with the Seismic consultant.
3. Equipment submittals shall include Seismic anchoring details.

H. HVAC Ductwork:

1. Attachments and supports for HVAC ductwork systems shall be designed to meet the force and displacement provisions of SEI/ASCE 7-05 Standard.

I. Piping

1. Attachments and supports for piping systems shall be designed to meet the force and displacement provisions of SEI/ASCE 7-05 Standard.

J. Mechanical Equipment, Attachments and Supports

1. Attachments and supports for mechanical equipment shall be designed to meet the force and displacement provisions of SEI/ASCE 7-05 Standard.

K. The Seismic details indicated on the drawings are not intended to limit the Contractor. Alternated methods of support, attachment and bracing must be designed by the Seismic Consultant and submitted to the Architect for review.

L. Sprinkler and standpipe system piping shall be supported and braced in accordance with NFPA 13 and NFPA 14.

## 2.3 RESILIENT PENETRATION SLEEVE/SEAL

A. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is 1/2 inch to 3/4 inch larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend one (1) inch beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4 inch of the ends of the sleeve. The remaining 1/4 inch space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through



the sleeve without contacting the sleeve. Alternatively, prefabricated sleeves accomplishing the same result are acceptable.

#### 2.4 RESILIENT LATERAL SUPPORTS

- A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements that are specifically designed to provide resilient lateral bracing of ducts or pipes.

#### 2.5 FLEXIBLE DUCT CONNECTIONS

- A. Flexible duct connections shall be made from coated fabric. The clear space between connected parts shall be a minimum of three (3) inches and the connection shall have a minimum of 1.5 inches of slack material.

#### 2.6 GROMMETS:

- A. Grommets shall be specially formed to prevent bolts from directly contacting the isolator base plate, and shall be sized so that they will be loaded within the manufacturer's recommended load range.
- B. Grommets shall either be custom made by combining a neoprene washer and sleeve, or a manufactured product:

#### 2.7 ACOUSTICAL SEALANT:

- A. Sealants for acoustical purposes as described in this specification shall be silicone or a nonsetting sealants.

#### 2.8 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
  - 1. Powder coating on springs and housings.
  - 2. All hardware shall be electrogalvanized. Hot-dip galvanized metal components for exterior use.
  - 3. Baked enamel for metal components on isolators for interior use.
  - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 APPLICATION:

- A. General:
  - 1. Refer to the PRODUCTS section of this specification for vibration isolation devices identified on the drawings or specified herein.
  - 2. The static deflections of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.
- B. Pipes:
  - 1. All chilled water, heating water, reheat water, preheat water, steam, and drain piping that is connected to vibration-isolated equipment shall be isolated from the building structure at their first three support points.
  - 2. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.
  - 3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2 inch, spring neoprene isolators shall be used. When the required static deflection is less than or equal to 1/2 inch, neoprene isolators shall be used. All other pipe support isolators within the specified limits shall be either neoprene achieving at least 1/4 inch static deflection.
  - 4. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
  - 5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
  - 6. Provide flexible pipe connections as called for under Major Equipment above and wherever shown on the drawings.
  - 7. All pipe risers within mechanical rooms over three (3) inches in diameter shall be isolated under each pipe riser floor support with either two layers of 3/4 inch thick, maximum 50 durometer neoprene pads or with load bearing plates or neoprene mounts with a minimum 0.2 inch static deflection.

C. Ductwork:

1. All sheet metal ducts and air plenums that are connected to vibration-isolated equipment shall be isolated from the building structure at their first three support points by neoprene isolators. All isolators shall achieve 0.1 inch minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
3. Flexible duct connections shall be provided as called for above under Major Equipment and wherever shown on the drawings.

3.3 INSTALLATION

A. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.

B. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.
3. In all cases, isolated electrical equipment shall be positioned so that it is free standing and does not come in rigid contact with the building structure or other systems.
4. Isolators:

- a. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
  - b. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
  - c. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
  - d. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
  - e. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
  - f. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.
  - g. Parallel running pipes may be hung together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and unisolated pipes on the same trapeze.
  - h. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
  - i. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
  - j. The installed and operating heights of equipment vibration-isolated with floor spring and neoprene travel limited isolators or roof isolators or with roof curb or roof rail isolation bases shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 inch clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
  - k. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.
  - l. Roof isolators shall be installed in strict accordance with the manufacturer's instructions.
5. Flexible Duct Connections:
- a. Sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so that the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.
6. Flexible Pipe Connections:

- a. Install flexible pipe connections in strict accordance with the manufacturer's instructions.
7. Thrust Restraints:
    - a. Thrust restraints shall be attached on each side of the fan at the vertical centerline of thrust. The two rods of the thrust restraint shall be parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.
  8. Grommets:
    - a. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.
  9. Resilient Penetration Sleeve/Seals:
    - a. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.
  10. Flexible Electrical Connections:
    - a. Type C connections shall be installed in a grossly slack "U" shape or a 360 degree loop.
    - b. Rigid conduit on the isolated-equipment side of the flexible connection, and the flexible connection itself, shall not be tied to the building construction or other rigid structures.
- C. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
  - D. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
  - E. 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.
  - F. Install resilient bolt isolation washers on equipment anchor bolts.

### 3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
1. Isolator seismic-restraint clearance.
  2. Isolator deflection.
  3. Snubber minimum clearances.
  4. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  5. Air-Mounting System Operational Test: Test the compressed-air leveling system. Remove malfunctioning units, replace with new units, and retest.
  6. Test and adjust air-mounting system controls and safeties. Replace damaged and malfunctioning controls and equipment.

### 3.5 ADJUSTING

- A. Adjust isolators after piping systems have been filled and equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.
- D. Adjust air spring leveling mechanism.
- E. Adjust active height of spring isolators.
- F. Adjust snubbers according to manufacturer's written recommendations.
- G. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.
- H. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

### 3.6 CLEANING

- A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

### 3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 1.

3.8 SEISMIC INSTALLATION INSPECTION

- A. On completion of installation of all vibration isolation and seismic restraint devices herein specified, a representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation or restraint devices, or other faults that could affect the performance of the system. Contractor shall submit a report to the Architect, including the manufacturer's representative's final report, indicating all isolation reported as properly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.
- B. All special inspections must be performed in accordance with IBC 2009 and as specified herein.
- C. Continuous inspection: The full-time observation of work by an approved special inspector pursuant to IBC 2009 section 1704. The following pieces of equipment require these inspections:
  - 1. All equipment using combustible or toxic energy sources.
  - 2. All electric motors, transformers, switchgear unit substations and motor control centers.
  - 3. Reciprocating and rotating type machinery.
  - 4. Pipe, 3" & larger.
  - 5. Tanks, heat exchangers & pressure vessels.
- D. Periodic inspection: intermittent observation of work by an approved special inspector of the following pieces of equipment in compliance with IBC 2009 section 1704.
  - 1. Isolator units for seismic isolation systems.
  - 2. All flammable, combustible and highly toxic piping and their associated mechanical systems.
  - 3. All ductwork containing hazardous materials.
  - 4. All electrical components for standby or emergency power systems.

END OF SECTION 15070

## SECTION 230593 - TESTING AND BALANCING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to work specified in this Section.

#### 1.2 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
  - 1. Air Systems:
    - a. Constant-volume air systems.
  - 2. Steam systems.
  - 3. HVAC equipment quantitative-performance settings.
  - 4. Existing systems TAB.
  - 5. Verifying that automatic control devices are functioning properly.
  - 6. Reporting results of activities and procedures specified in this Section.

#### 1.3 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. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. 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.
- E. NC: Noise criteria.
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. RC: Room criteria.



- H. Report Forms: Test data sheets for recording test data in logical order.
- I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.
- J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.
- K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.
- L. 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.
- M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- O. 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.
- P. TAB: Testing, adjusting, and balancing.
- Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- R. Test: A procedure to determine quantitative performance of a system or equipment.
- S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

#### 1.4 QUALIFICATIONS

- A. Work included in this section must be performed by an independent testing and balancing agency and an approved member of the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) who shall provide a complete and comprehensive total system balance process to test, adjust, and balance the air and water systems for this project. Submit the name of the air balance firm for approval within thirty (30) days after award of contract. See Section 15000 for approved Contractors.
- B. If the Contractor fails to submit the name of an acceptable agency within the specified time, the (Architect/Engineer) will select a firm to accomplish the work, and the selection shall be binding at no additional cost to the Owner.
- C. All work shall be performed under direct supervision of a qualified engineer. All instruments

used shall be accurately calibrated and maintained in good working order. If requested, calibration tests of equipment to be used shall be performed in the presence of the (Architect/Engineer).

- D. Submit for review and approval within ten (10) working days after the notice to proceed, the names of the personnel who will be responsible for the work and those who will actually perform the testing and balancing and their qualification, which shall demonstrate that they have balanced and tested systems of comparable size and complexity.

## 1.5 SUBMITTALS

- A. Qualification Data: Submit evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Submit Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Submit TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- D. Certified TAB Reports: Submit reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- E. Warranties specified in this Section.

## 1.6 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.
- B. TAB Conference: Meet with Owner's and Architect's representatives on approval of 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 installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
  - 1. Agenda Items: Include at least the following:
    - a. Submittal distribution requirements.
    - b. The Contract Documents examination report.
    - c. TAB plan.
    - d. Work schedule and Project-site access requirements.
    - e. Coordination and cooperation of trades and subcontractors.
    - f. Coordination of documentation and communication flow.
- C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
  2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
- E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems and NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."
- F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by the instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

#### 1.7 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

#### 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 seven days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

#### 1.9 WARRANTY

- A. National Project Performance Guarantee: If AABC standards are used, provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air

Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

- B. Special Guarantee: If NEBB standards are used, provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
- C. Guarantee includes the following provisions:
  - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
  - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

#### 1.10 TEST PROCEDURE

- A. System may be tested in sections when approved by the (Architect/Engineer).
- B. When testing and balancing involve the building temperature control systems, cooperate with the temperature control subcontractor to achieve the desired results.
- C. At the time of final inspection, recheck in the presence and at the request of the (Architect/Engineer) not to exceed ten (10) percent of the previously recorded readings from the certified report selected at random from the log by the (Architect/Engineer).
- D. Permanently mark the settings of valves, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Do not permanently mark devices before final acceptance.
- E. Perform all tests in accordance with AABC standard procedures. Any deviation from same must be approved by the (Architect/Engineer).
- F. Should the basic system or any of its components fail to meet contract requirements, and thereby make the testing and balancing work invalid, notify the (Architect/Engineer) and stop all tests until such time that the failure is corrected.

### PART 2 - PRODUCTS

#### 2.1 TEST INSTRUMENTS

- A. Use instruments of equal or better quality than those described in the technical portions of Associated Air Balance Council--"National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, Fifth Edition 1989.
- B. Instruments used for balancing air and water systems must have been calibrated within a period

of six (6) months prior to balancing.

- C. List in the report types, serial numbers, and dates of calibration of all instruments used in the final air and water balance tests.
- D. Instrumentation shall include, as a minimum, the following items of equipment:
  - 1. Pressure gauges and fittings.
  - 2. Dry bulb and wet bulb thermostats.
  - 3. Contact pyrometer.
  - 4. Portable flow meter and, if required, orifice plates.
  - 5. Pitot tube and manometers.
  - 6. Alnor Velometer with attachments.
  - 7. Amprobe.
  - 8. Tachometer.
  - 9. Special wrenches and tools.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
  - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
  - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine project record documents described in Division 1 Section "Project Record Documents."
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce 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.

- F. 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.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- L. Examine strainers for clean screens and proper perforations.
- M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- O. Examine system pumps to ensure absence of entrained air in the suction piping.
- P. Examine equipment for installation and for properly operating safety interlocks and controls.
- Q. Examine automatic temperature system components to verify the following:
  - 1. Dampers, valves, and other controlled devices are operated 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, mixing boxes, and variable-air-volume terminals.
  - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
  - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, 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.

9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

- R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

### 3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
  2. Hydronic systems are filled, clean, and free of air.
  3. Automatic temperature-control systems are operational.
  4. Equipment and duct access doors are securely closed.
  5. Balance, smoke, and fire dampers are open.
  6. Isolating and balancing valves are open and control valves are operational.
  7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
  8. Windows and doors can be closed so indicated design conditions for system operations can be met.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. All air distribution systems including supply, return, outdoor air and exhaust ductwork shall be tested and balanced.

- B. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- C. Prepare schematic diagrams of systems' "as-built" duct layouts.
- D. For variable-air-volume systems, develop a plan to simulate diversity.
- E. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- F. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- G. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- H. Verify that motor starters are equipped with properly sized thermal protection.
- I. Check dampers for proper position to achieve desired airflow path.
- J. Check for airflow blockages.
- K. Check condensate drains for proper connections and functioning.
- L. Check for proper sealing of air-handling unit components.
- M. Check for proper sealing of air duct system.
- N. Where the system cannot be properly balanced or equipment tested due to system deficiencies such as inability to properly adjust fan speeds, improperly sized motors, excessively noisy equipment, malfunctioning controls, excessively out of balance air distribution system branch runs, and similar items, furnish to the (Architect/Engineer) in writing a list of the deficiencies prior to the submission of the test report.
- O. Verify operation of each room thermostat serving variable air volume terminal units over full range of heating and cooling to insure proper sequence of control of the variable air volume operator and reheat coil valve.
- P. Field test maximum and minimum air volumes of all variable air volume terminal units and record final settings. Check factory settings of regulators and controllers before tests. Reset to the scheduled air volumes if required.
- Q. Air Outlets and Inlets: Adjust total to within plus or minus 10 percent of design to space. Adjust individual outlets and inlets in space to within plus or minus 10 percent of design.
- R. Work in conjunction with the Automatic Temperature Control Contractor and Architect to establish maximum and minimum settings on all variable air volume fans.



### 3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by the fan manufacturer.
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 component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
    - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
  3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.
  4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
  5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
  6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
    - a. Where sufficient space in submains and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
  2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.

- C. Measure terminal outlets and inlets without making adjustments.
  - 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
  - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
  - 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

### 3.6 PROCEDURES FOR STEAM SYSTEMS

- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
- C. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record the final setting.
- D. Check the settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.

### 3.7 GENERAL PROCEDURES FOR EQUIPMENT

- A. Conduct performance tests only after the air and water systems have been balanced and the proper flow rates established.
- B. Test and record capacity of heat transfer equipment including all coils. Air side and water side capacities must agree within five (5) percent of each other. Include the manufacturer's rated capacity at the test operating conditions with the report. Perform tests where possible at design conditions. If tests are not performed under design conditions, interpolate results to determine capacity at full load operating conditions.
- C. Calculate efficiency of pumps and fans by recognized methods using test data.
- D. Test refrigeration equipment to determine heat extracted from or heat added to the building by the equipment and the heat ejected from the device. Record date, time and outside weather conditions including ambient dry bulb, wet bulb, wind speed and direction, cloud cover, rain, and any special conditions pertinent to the test.

### 3.8 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Steam Coils: Measure the following data for each coil:
1. Dry-bulb temperature of entering and leaving air.
  2. Airflow.
  3. Air pressure drop.
  4. Inlet steam pressure.

### 3.9 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
1. Measure and record the operating speed, airflow, and static pressure of each fan.
  2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
  3. Check the refrigerant charge.
  4. Check the condition of filters.
  5. Check the condition of coils.
  6. Check the operation of the drain pan and condensate drain trap.
  7. Check bearings and other lubricated parts for proper lubrication.
  8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
1. New filters are installed.
  2. Coils are clean and fins combed.
  3. Drain pans are clean.
  4. Fans are clean.
  5. Bearings and other parts are properly lubricated.
  6. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
  2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
  3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
  4. Air balance each air outlet.

### 3.10 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the 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.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

### 3.11 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, 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.
- B. 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. Prepare a separate report for each system and each building floor for systems serving multiple floors.

### 3.12 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and

balancing engineer.

1. Include a list of 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.
5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:
  - a. Indicated versus final performance.
  - b. Notable characteristics of systems.
  - c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms, including the following:
  - a. Settings for outside-, return-, and exhaust-air dampers.
  - b. Conditions of filters.
  - c. Cooling coil, wet- and dry-bulb conditions.
  - d. Face and bypass damper settings at coils.
  - e. Fan drive settings, including settings and percentage of maximum pitch diameter.
  - f. Inlet vane settings for variable-air-volume systems.
  - g. Settings for supply-air, static-pressure controller.
  - h. Other system operating conditions that affect performance.

- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outside, supply, return, and exhaust airflows.
  2. Water and steam flow rates.
  3. Duct, outlet, and inlet sizes.
  4. Pipe and valve sizes and locations.
  5. Terminal units.
  6. Balancing stations.
  7. Position of balancing devices.
- F. Apparatus-Coil Test Reports:
1. Coil Data:
    - a. System identification.
    - b. Location.
    - c. Coil type.
    - d. Number of rows.
    - e. Fin spacing in fins per inch
    - f. Make and model number.
    - g. Face area in sq. ft..
    - h. Tube size in NPS.
    - i. Tube and fin materials.
    - j. Circuiting arrangement.
  2. Test Data: (Indicated and Actual Values):
    - a. Airflow rate in cfm.
    - b. Average face velocity in fpm.
    - c. Air pressure drop in inches wg.
    - d. Outside-air, wet- and dry-bulb temperatures in deg F.
    - e. Return-air, wet- and dry-bulb temperatures in deg F.
    - f. Entering-air, wet- and dry-bulb temperatures in deg F.
    - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
    - h. Water flow rate in gpm.
    - i. Water pressure differential in feet of head or psig.
    - j. Entering-water temperature in deg F.
    - k. Leaving-water temperature in deg F.
    - l. Refrigerant expansion valve and refrigerant types.
    - m. Refrigerant suction pressure in psig.
    - n. Refrigerant suction temperature in deg F.
    - o. Inlet steam pressure in psig.
- G. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:

- a. System and air-handling unit number.
- b. Location and zone.
- c. Traverse air temperature in deg F.
- d. Duct static pressure in inches wg.
- e. Duct size in inches.
- f. Duct area in sq. ft.
- g. Indicated airflow rate in cfm.
- h. Indicated velocity in fpm.
- i. Actual airflow rate in cfm.
- j. Actual average velocity in fpm.
- k. Barometric pressure in psig.

### 3.13 INSPECTIONS

#### A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:
  - a. Measure airflow of at least 10 percent of air outlets.
  - b. Measure water flow of at least 5 percent of terminals.
  - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
  - d. Measure sound levels at two locations.
  - e. Measure space pressure of at least 10 percent of locations.
  - f. Verify that balancing devices are marked with final balance position.
  - g. Note deviations to the Contract Documents in the Final Report.

#### B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report

- and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

#### 3.14 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspections, and adjusting during near-peak summer and winter conditions.

END OF SECTION 15990



## SECTION 230700 – MECHANICAL SYSTEMS INSULATION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

#### 1.2 SCOPE

- A. Work included in this section is the thermal insulating done in the field, on the Division 21, 22 and 23 systems as specified herein.
- B. Work excluded in this Section are the following:
  - 1. Thermal building insulation.
  - 2. Sound absorbing duct lining.
- C. The requirements of Division 23, Section "Mechanical and Electrical General Provisions" shall apply to the work specified under this Section.

#### 1.3 DEFINITIONS

- A. The k factor means the number of British thermal units of heat transmitted per (sq. ft.) (Fahrenheit temperature difference) through a material with flat, parallel sides one (1) inch apart. The material shall be tested and rated according to ASTM Test Method C-177.
- B. Unless otherwise specified, the term "concealed", as used in this specification, shall include all items hidden from normal sight. This includes items within furred spaces, pipe and duct shafts, above suspended ceilings and within return air plenums.
- C. Unless otherwise specified, the work "exposed" shall refer to all work other than "concealed" work.
- D. Unless otherwise specified, the term "exterior", as used in this specification, shall include all items being or situated outside. Items located within a crawl space shall be considered exterior.
- E. Unless otherwise specified, the term "conditioned", as used in this specification, shall be a heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means, so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.

#### 1.4 SUBMITTALS

- A. Provide shop drawings in accordance with Division 23, Sections "Mechanical and Electrical General Provisions" and the General Requirements which shall include all insulation, jackets, finishes, corner beads, pump covers, etc. Shop drawings shall additionally describe each system or component to be insulated, insulation type and thickness, and method of installation.
- B. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail attachment and covering of heat tracing inside insulation.
  - 3. Detail insulation application at pipe expansion joints for each type of insulation.
  - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 5. Detail removable insulation at piping specialties.
  - 6. Detail application of field-applied jackets.
  - 7. Detail application at linkages of control devices.

#### 1.5 MOCK-UPS

- A. Mockups: Before installing insulation of any type, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:
  - 1. Include the following mockups:
    - a. One 10-foot section of 2" straight pipe and duct run.
    - b. One 90-degree pipe and duct elbow.
    - c. One pipe and duct tee fitting.
    - d. One 2" valve.
    - e. Four support hangers, including hanger shield and insert.
  - 2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.
  - 3. Build mockups in the location indicated or, if not indicated, as directed by Architect.
  - 4. Notify Architect seven (7) days in advance of dates and times when mockups will be constructed.
  - 5. Obtain Architect's approval of mockups before starting insulation application.
  - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
  - 7. Demolish and remove mockups when directed.

## 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

## 1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields.
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

## 1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

## PART 2 - PRODUCTS

### 2.1 GENERAL

- A. All insulating materials, including adhesives, jackets and coatings, to be used on the project must be delivered to the building in the manufacturer's unopened container and must bear the manufacturer's stamp or label giving name of manufacturer, brand and description of material.

- B. After the necessary tests have been conducted to prove the water and air systems tight, all piping, ductwork and equipment to be insulated shall be thoroughly cleaned and then covered. Insulation materials shall be the product of Owens Corning, CSG, Schuller or Armacell equal to the products specified herein.
- C. All Insulation shall have ASTM E84 flame spread/smoke developed indices of  $\leq 25/50$  for use in air plenums of commercial buildings.

## 2.2 TYPES OF INSULATION

- A. Type I - Pipe Insulation:
  - 1. Provide heavy density fiberglass pipe insulation with vapor barrier jacket. The k factor shall not be more than 0.23 at seventy-five (75) degrees Fahrenheit mean temperature. Insulation shall be equal to Johns Manville Micro-Lok meeting ASTM C 547 with FSK jacket.
- B. Type II - Pipe Insulation:
  - 1. Provide closed cell elastomeric tubular insulation with built-in vapor barrier. The k factor shall not be more than 0.25 at seventy-five (75) degrees Fahrenheit mean temperature. Insulation shall be equal to Armacell AP Armaflex or AP Armaflex SS. The use of polyethylene, polyolefin or engineered polymer insulation is prohibited.
- C. Type IV - Duct Insulation:
  - 1. Provide blanket type lightweight fiberglass duct insulation with vapor barrier facing. The compressed k-factor shall not exceed 0.27 at seventy-five (75) degrees Fahrenheit mean temperature and a minimum installed R-Value of 6.0 (hr•ft<sup>2</sup>•°F)/Btu. Insulation shall be equal to Johns Manville flexible fiberglass blanket Microlite XG Formaldehyde-free Type 100 meeting ASTM C 553 with factory-applied FSK facing.
- D. Type V - Duct and Equipment Insulation:
  - 1. Provide board type fiberglass insulation with vapor barrier facing. The k factor shall not exceed 0.22 at seventy-five (75) degrees Fahrenheit mean temperature, and the density shall not be less than 6.0 pounds per cubic foot (pcf). Insulation shall be equal to Johns Manville 817 Spin-Glas meeting ASTM C 612 with FSK facing.
- E. Type VI - Equipment Insulation:
  - 1. Provide board type fiberglass insulation, unfaced. The k factor shall not exceed 0.23 at seventy-five (75) degrees Fahrenheit mean temperature and the density shall not be less than 3.0 pounds per cubic foot (pcf). Insulation shall be equal to Johns Manville 814 Series Spin-Glas meeting ASTM C 612.
- F. Type VII - Equipment or Exterior Duct Insulation:

1. Provide flexible elastomeric thermal sheet insulation with built-in vapor barrier. The k factor shall not exceed 0.27 at seventy-five (75) degrees Fahrenheit mean temperature. Insulation shall be equal to Armacell AP Armaflex or AP Armaflex SA.

G. Type IX - Equipment Insulation:

1. Provide flexible board type fiberglass insulation, unfaced. The k factor shall not exceed 0.28 at 150 degrees Fahrenheit mean temperature. Insulation shall be equal to Johns Manville pipe and tank insulation.

H. Type XI – Fire Barrier Insulation

1. Provide patented inorganic blanket encapsulated with scrim reinforced foil insulation with k-factor of 0.21. Wrap shall be rated as a shaft alternative per UL 1978. Insulation shall be equal to 3M Fire Barrier Insulation 15A.

I. Type XII – Piping Insulation

1. Provide rigid closed-cell polyisocyanurate thermal insulation with vapor retarder over pipe insulation and 0.030 inch thick PVC (polyvinylchloride) rolled jacketing. The insulation shall have a density of 2 lb/ft<sup>3</sup>, the k factor shall not be more than 0.18 (aged 6-months) at seventy-five (75) degrees Fahrenheit mean temperature and the minimum R-value of 5.6 hr\*ft<sup>2</sup>\*F/BTU (aged 6-months). Polyisocyanurate pipe insulation shall be manufactured by Dyplast, Dow Chemical Company, Elliott Company, or Duna USA equal to Dyplast dP-ISO-C1.

## 2.3 ADHESIVES, SEALERS AND COATINGS

- A. The vapor barrier on all insulation systems shall be maintained at all times. Any penetration into the vapor barrier shall be sealed vapor tight. All joints, fittings etc shall be sealed vapor tight.
- B. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. They shall not corrode, soften or otherwise attach such material in either the wet or dry state and must be suitable for the service temperatures.
- C. Any cement, sealer or coating used shall be resistant to vermin and mold and shall be durable. It shall not discolor on aging; and where applied on the final surface of the insulation, it shall be light in color and be capable of being painted.
- D. For indoor applications:
  1. Use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  2. Use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Adhesives, coatings and compounds shall be equal to the following:

1. Vapor barrier adhesive for sealing joints on pipe and duct insulation - Foster 85-75.
2. Adhesive for installing canvas jackets - Foster 30-36.
3. Adhesive for installing duct insulation - Foster 85-20 and 81-91.
4. Adhesive for installing cellular-glass insulation - Foster Brand 81-84.
5. Adhesive for installing elastomeric insulation - Foster Brand 85-75, Armaflex 520.
6. Adhesive for installing mineral-fiber insulation - Foster Brand 85-60/85-70, Childers CP-127.
7. Adhesive for ASJ, FSK and PVDC jackets - Foster Brand 85-50, Childers CP-82.
8. Joint sealants for cellular-glass insulation - Foster Brand 30-45, Childers CP-76.
9. FSK and metal jacket flashing sealants - Foster Brand 95-44, Childers CP-76.
10. ASJ, vinyl, PVDC, and PVC jacket flashing sealants - Childers Brand CP-76
11. Two coats of WB Armaflex finish or glass mesh with mastic for all Armaflex located outside.

#### 2.4 FABRIC JACKETS

- A. All exposed piping, ductwork, and equipment in addition to the insulation jackets specified, shall be covered with an additional UL listed jacket of eight (8) ounce canvas. This shall be in addition to the insulation jackets specified.

#### 2.5 PAINTING

- A. All piping and insulation in the mechanical rooms shall be painted. Refer to Division 23 Section "Basic Materials and Methods" and Division 9 for more information.

#### 2.6 FITTING AND VALVE COVERS

- A. Pipe fittings and valves shall be insulated with one (1) piece pre-molded high impact PVC insulated fitting covers with factory pre-cut insulation inserts and accessories. Fittings shall have edges of one (1) piece cover sealed with vapor barrier pressure sensitive tape. Fitting covers shall be 25/50 rated to meet fire and smoke safety requirements of federal, state and local building codes. Manufacturers shall be Knauf (Proto), Johns Manville (Zeston), Thomas Insulation or equal to Proto Fitting Cover System.

#### 2.7 METALLIC COMPONENTS

- A. Staples shall be outward clinching type of 304 or 316 stainless steel.
- B. Bands shall be galvanized steel, aluminum, brass, or nickel-copper alloy, of 3/4 inch nominal width. The band thickness, exclusive of coating, shall be not less than 0.005 inch for steel and nickel copper alloy, 0.007 inch for aluminum, and 0.01 inch for brass.

- C. Wire shall be fourteen (14) gauge, nickel-copper alloy or copper clad steel, or sixteen (16) gauge, soft annealed, galvanized steel.
- D. Wire netting used for exposed surfaces of insulation that is to be cement finished shall be twenty-two (22) gauge, one (1) inch galvanized mesh, with continuous twenty-six (26) gauge galvanized steel corner beads having 2-1/2 inch wings.
- E. Protect external corners on insulation of ducts and equipment exposed in occupied spaces by corner beads two (2) inches by two (2) inches, .016 inch thick aluminum adhered to heavy duty Kraft paper.
- F. All exterior piping and ductwork shall be additionally covered with a sixteen (16) mil embossed aluminum weatherproof jacket. Jacketing shall be ITW's Lock-On (Childers) type with an integrally bonded polysurlyn moisture retarder over the entire surface in contact with the insulation. Jackets are to be fabricated with continuous modified Pittsburgh Z-lock on the longitudinal seam and each butted section of jacketing shall be joined and sealed with factory fabricated butt strap and sealant. Fittings shall be insulated and weatherproofed using similar materials.

2.8 INSULATION SCHEDULE:

- A. Insulation materials furnished must meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1 (current accepted edition), "Energy Efficient Design of New Buildings" of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE).

Service	Type	Thickness
B. Domestic Water Pipe (Hot, Cold, Tempered, & Recirc.,) Optional sizes 1" and smaller	I	1"
	I	1/2"
C. Domestic Water Piping Concealed in Walls and Cabinet Enclosures	II	1/2"
D. Air Conditioning Condensate Optional	I	1"
	II	1/2"
E. Steam and Condensate		
1. 1 1/2" or smaller	I	1 1/2"
2. 2" and larger	I	2"
F. Air Conditioning Supply and Outdoor Air Ductwork		
1. Concealed	IV	2"

2.	Exposed or in Shafts	V	2"
3.	Air Device Bodies	V	1"
G.	Air Conditioning Return Ductwork		
1.	Concealed (shafts only)	IV	2"
2.	Exposed	V	1"

### PART 3 - EXECUTION

#### 3.1 GENERAL:

- A. All insulation shall be installed by skilled workmen regularly engaged in this type of work.
- B. Insulation shall be continuous at all hangers, hanger rods, supports, sleeves and openings. Continuous vapor barrier must be provided for all cold surfaces. Insulation shall be sealed where it terminates because of a valve, union, flange, etc.
- C. Provide continuous insulation and jacketing when passing thru interior wall, floor, and ceiling construction.
  - 1. At Through Penetration Firestops: Coordinate insulation densities with the requirements of approved firestop system being installed.
  - 2. Insulation densities required by approved firestop system may vary with the densities specified in this Section. When this occurs use the higher density insulation.
- D. Do not intermix different insulation materials on individual runs of piping or ductwork.
- E. Arrange to permit expansion and contraction without causing damage to insulation or surface.
- F. Actual insulation thickness must be at least equal to the minimum specified in the schedule at all locations including supports in contact with cold surfaces. Where the manufacturer's rated or nominal thickness is less than the minimum specified, a thicker material or more layers will be requested so that the stated minimum thickness will be attained or exceeded.
- G. Install insulation materials in a first class manner with smooth and even surfaces. Scrap pieces of insulation shall not be used where a full length section will fit.
- H. Unless otherwise specified herein, the application of all insulation materials, accessories and finishes shall be in accordance with the manufacturer's published recommendations.
- I. Insulation materials shall not be applied until all surfaces to be covered are clean and dry; all foreign material, such as rust, scale, dirt, etc., has been removed, and where specified, surfaces have been painted. Insulation shall be clean and dry when installed and during the application



of any finish. The insulation on pipe fittings, valves and pipe joints shall not be installed before the piping is tested and approved.

- J. Omit insulation of the following unless directed otherwise.
  - 1. Brass or copper pipe specified to be chrome plated.
  - 2. Traps and pressure reducing valves, relief piping from safety valves, and unions, flanges and expansion joints on heating water system.
  - 3. All fire protection piping.
  - 4. Existing adjacent insulation.
  - 5. ASME stamps, manufacturer's nameplates.
  - 6. Access plates on fan housings.
  - 7. Cleanouts or handholes.
  - 8. Components within factory preinsulated HVAC equipment.
  - 9. Factory - preinsulated flexible ductwork and HVAC equipment.
  - 10. Vibration - isolating connections.
  
- K. Replace and repair insulation disturbed by testing and balancing procedures required under Division 23, Section "Testing and Balancing".
  
- L. Repair existing insulation on piping, ductwork, and equipment, that is damaged by the contractor's work with a material similar to the existing insulation. Insulation vapor barrier and appearance shall be returned to its original condition.

### 3.2 PIPE INSULATION

- A. High density pipe saddles shall be provided at all points of support as hereinbefore specified.
  
- B. Insulate all valves and strainers. Use premolded covers and factory precut insulation where applicable. Unions and flanges shall not be insulated except on cold services.
  
- C. Insulate valves up to and including bonnets, except for cold water valves which shall be insulated over packing nuts in a manner to permit removal for adjustment and repacking.
  
- D. Insulate strainers in a manner to permit removal of the basket without disturbing the insulation of the strainer. Obtain Architect's approval of installation method.
  
- E. Insulate all exposed piping under lavatories and sinks with a white, fitted/molded antimicrobial undersink pipe cover equal to Truebro Lav Guard 2. Cover shall have internal, E-Z Tear-To-Fit trim feature for square, clean trimming (internal ribs) and built-in, concealed E-Z Grip fasteners (no cable-tie fasteners allowed).
  
- F. Application - Type I Insulation:
  - 1. Insulate all pipes in a neat and workmanlike manner. Seal all longitudinal laps of jackets and staple every six (6) inches. Where the piping operates below ambient temperature, the staples shall be coated with vapor barrier adhesive. All butt joints shall be wrapped with a three (3) inch minimum wide strip of jacketing material securely sealed in place.

2. Insulate valves and fittings with pre-cut blanket type fiberglass insulation and PVC covers as specified. Insulation shall be of the same thickness as that on adjoining pipe. The ends of the insulation shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe covering tufted and tucked, fully insulating the pipe fitting. The one (1) piece PVC fitting cover shall then be secured by stapling, tack fastening, banding or taping the ends to the adjacent pipe covering. Chilled water supply and return piping and cold water systems piping shall be insulated as above and have all seam edges of the cover sealed with ZESTON vapor barrier adhesive mastic. The circumferential edges of cover shall be wrapped with ZESTON vapor barrier pressure sensitive color matching tape. The tape shall extend over the adjacent pipe insulation and overlap itself at least two (2) inches on the downward side.
3. Where fittings are operating above ambient they may, in lieu of the proceeding paragraph, be covered with a three (3) hour, hydraulic setting, combination insulating and finishing cement having k factor not greater than 0.87 at a mean temperature of 200 degrees Fahrenheit. The thickness of this cement shall be such that the surface is substantially flush with the pipe covering. Where the insulation terminates at a fitting that is not covered, the end of the insulation shall be beveled off with this same cement. All fittings insulated in this manner shall be covered by a fabric jacket as specified, which shall be cemented down with lagging adhesive.
4. Where expansion joints are required to be insulated, they shall be covered with readily removable sections of insulation of same composition and thickness as provided for adjacent piping.

G. Application - Type II Insulation:

1. The material shall be slit lengthwise to permit installation or slipped over pipe before connections are made. Self-seal insulation may also be installed.
2. All joints and seams must be thoroughly bonded, both mechanically and hermetically, by the adhesive recommended by the insulation manufacturer. Also, the manufacturer's recommendations shall be followed as to the adhesive to use where the insulation needs bonding to metal or other material used for any surface treatment where a finish coat of paint is required.
3. All penetrations of the insulation must be thoroughly sealed so that the insulation itself will form a complete vapor barrier. Insulation shall run continuous at hangers and supports to form a complete vapor barrier. Wherever the insulation terminates, the edges shall be sealed to the metal.
4. Insulation shall be extended to stop valves under plumbing fixtures and/or within cabinets. Water and waste lines serving handicap plumbing fixtures shall be insulated and painted to match adjacent surface.

H. Application -Type XII Insulation:

1. Insulation shall be fabricated in required shapes from bun stock in accordance with ASTM C-450 "Standard Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments" and C-585 "Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)". Insulation shall be factory fabricated by a qualified fabricator from bun stock.

2. Fittings, such as valves, valve stations, flanges, 90° and 45° elbows, and tees shall be two piece flycut or routed as the preferred fabrication method. For diameters too large for flycutting or routing, the pieces shall be fabricated in two halves with each half made up of mitered sections. Both methods shall be in accordance with ASTM C-450 and ASTM C-585.
3. Adhesives, Joint Sealers and Mastics
  - a. Solvent based adhesives, joint sealers and mastics may be used in contact with ISO-C1 insulation. Mastics shall remain flexible at the lowest expected ambient temperature.
  - b. Joint sealers for sealing joints of insulation shall be vapor retarder type, moisture and water resistant, non hardening, and flexible with a service temperature range from -275°F to +200°F.
  - c. A vapor retarder type joint sealer shall be applied on insulation longitudinal joints and butt joints to prevent moisture and moisture vapor infiltration. Such joint sealers are Fosters 95-50 sealer or approved equal. Please consult joint sealer manufacturer for recommended products
  - d. Solvent or water adhesives may be used to attach the vapor barrier to the outer surface of the ISO-C1. Refer to the vapor barrier installation guidelines. Consult adhesive manufacturer's literature for instructions on handling adhesives including required operating temperatures. Potential adhesives for use in this application include:
    - 1) Childers CP 88 adhesive (solvent based)
    - 2) Foster 81-05 adhesive (solvent based)
    - 3) Foster 85-50 adhesive (water based)
    - 4) Foster 85-60 adhesive (water based)
4. Vapor Retarder
  - a. The Vapor Retarder be factory or field applied to the outer surface of the pipe insulation. A double layer vapor retarder design shall be used for cryogenic and LNG applications, with the secondary vapor retarder applied between the outer most foam insulation layer and the next inner layer of foam insulation. Refer to Figure 2 in Appendix B for details.
  - b. Vapor retarder shall have a maximum permeance of 0.01 perm and shall be equivalent to Venture Wrap or Venture Clad products or Insulrap 50 Laminated Vapor Retarder for Pipe Insulation. Refer to ASTM standards C-755 and C-1136 for information on selection and specification of vapor retarders. Refer to product literature and installation guidelines from the vapor retarder manufacturer for recommended application instructions.
  - c. Elbows and fittings shall be wrapped with vapor retarder tape with a 50% overlap.
  - d. For other laminated membrane type vapor retarders, consult manufacturer's literature and installation guidelines.
5. Installation
  - a. Dyplast recommends insulation shall be fabricated with shiplap or tongue and groove longitudinal joints and shiplap ends.

- b. Install pre-fabricated insulation fittings on elbows, tees, and valves. Insulation shall be the same thickness as pipe sections and fabricated with shiplap ends and shiplap or tongue and groove longitudinal joints.
- c. Insulation shall be secured to the pipe with 3/4" wide fiber reinforced tape.
- d. Insulation shall be secured with fiber reinforced tape prior to installation of the vapor retarder material when vapor retarder is field applied.
- e. Outer layer insulation and vapor retarder shall be secured with fiber reinforced tape. Use a 25% circumferential overlap on 12" centers when vapor retarder is factory applied to insulation. Fiber tape shall be applied to the exterior of the insulation/vapor retarder system.
- f. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor retarder must be continuous. All fasteners and bands shall be neatly aligned and overall work must be of high quality appearance and workmanship.
- g. Vapor stops shall be used on either side of valves frequently removed for servicing, valve stations left exposed, or odd fittings, elbows, tees, etc. where the chance of moisture infiltration is high.
- h. The vapor retarder shall have a maximum permeance of 0.01 perm and shall be equivalent to Venture wrap or Venture Clad products or Insulrap 50 Laminated Vapor Retarder.
- i. Vapor Retarder Film should be cut to length longitudinally and wrapped around the circumference of the pipe with lap joint and installed facing downward avoiding the placement of the joint at the top or bottom of the pipe. Lap joint to be sealed using liquid adhesive. Butt joints shall be covered with Vapor Retarder Tape. Spiral wrap configuration can be used in lieu of the above installation. Spiral wrapping will require adhesive placed on one edge of the vapor retarder as it is wrapped over the previous layer.
- j. Elbows and fittings shall be wrapped with Vapor Retarder Tape or covered with a mastic type vapor retarder product. Vapor Retarder Tape is to be wrapped in a spiral configuration. If using mastic type vapor retarder at fittings and elbows, form mastic so that fitting covers can be applied true and tight.
- k. On factory applied Vapor Retarder Film, lap joint to be sealed with SSL tape. All vapor retarder surfaces should be cleaned and free of dust, grease, oil, etc before application of the SSL tape to ensure good adhesion between the tape and vapor retarder. Refer to Figure 7 in Appendix. For other types of factory applied vapor retarders, consult manufacturer's recommendations on installation.
- l. Before jacketing can be installed on a portion of the piping, the vapor retarder system on that portion must be complete and continuous.

### 3.3 DUCT INSULATION

- A. Provide accessories as required to prevent distortion and sagging of duct insulation. Provide welded pins, adhesive clips and wire ties as recommended by the manufacturer and directed by the Architect.
- B. Insulation shall cover all standing seams and metal surfaces. Provide corner beading on all exposed ducts.
- C. Staples shall be sealed to maintain vapor barrier.

- D. Neatly cut insulation at dampers, temperature control sensors, and controllers. Butter exposed edges with approved mastic coating.
- E. Use 24" minimum length Type V board type insulation , of specified thickness, on the bottoms of ducts at each trapeze hanger location.
- F. Application - Type IV Insulation:
  - 1. Insulation shall be cut slightly longer than perimeter of duct to insure full thickness at corners. All insulation shall be applied with edges tightly stitched with staples. Provide vapor barrier mastic sealer at seam. The insulation shall be additionally secured to the bottom of all square ducts eighteen (18) inches or wider by means of welded pins and speed clips. The protruding ends of the pins shall be cut off flush after the speed clips have been applied. The vapor barrier facing shall be thoroughly sealed where the pins have pierced through with a tape of the same material by applying a vapor barrier adhesive to both surfaces as recommended by the manufacturer.
  - 2. All hanger rods, support members, joints and penetrations of the vapor barrier shall be sealed with full thickness insulation and vapor barrier mastic sealer. All cuts or tears shall be sealed with strips of the aluminum foil tape and vapor barrier adhesive.
- G. Application - Type V Insulation:
  - 1. All insulation shall be applied with edges tightly butted. Insulation shall be impaled on pins welded to the duct and secured with speed clips. Spacing of pins shall be as required to hold insulation firmly in place but not less than one (1) pin per square foot, and pins shall be placed within three (3) inches of each corner of insulation. All joints and penetrations of the vapor barrier shall be sealed with a three (3) inch wide strip of the same material, applied with Foster 85-75, or to both surfaces as recommended by the adhesive and vapor barrier mastic sealer manufacturer.
  - 2. If, through space or size restriction or other causes, the welded pin method is impossible, the insulation shall be secured to the duct with adhesive such as Foster 81-91 or equal. The adhesive shall cover the entire surface of the sheet metal when applied to underside of horizontal duct but may be applied in strips or spots for application to top and sides with a minimum of fifty (50) percent coverage.

### 3.4 FABRIC JACKET

- A. Apply jacket to insulated breeching and equipment. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 at the rate of sixty (60) to seventy (70) square feet per gallon. Embed into wet coating the canvas jacket, smoothed out to avoid wrinkles and overlap all seams a minimum of two (2) inches. Apply a second brush coat of Sealfas 30-36 to the entire surface at the rate of sixty (60) to seventy (70) square feet per gallon.
- B. Where jacket is to be installed on piping, apply Foster 30-36 adhesive to the canvas jacket by dipping to completely wet and saturate the canvas. While wet, position on the pipe insulation and pull tight, bond, lap and smooth out all wrinkles. Finish with a sealer coat of adhesive.

University of South Carolina  
Career Center at Thomas Cooper Library  
BID SET  
**Addendum No.1**

Architect's Project No. 12.130.03  
University Project No. H27-1998-A  
04/08/13  
**04/10/13**

END OF SECTION 230700

## SECTION 233110 – AIR DISTRIBUTION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

#### 1.2 SCOPE

- A. This section includes the air distribution systems including those devices distributing the air to the spaces, and those items which collect, filter, control, and convey air.
- B. Fans which are not an integral part of a factory fabricated air handling unit are included under this section.
- C. The requirements of Division 23, Section “Mechanical and Electrical General Provisions” shall apply to the work specified under this section.
- D. Except for duct pressure tests, all testing and balancing of the air distribution systems shall be performed under Division 23, Section “Testing and Balancing” of the Specifications.

### PART 2 - PRODUCTS

#### 2.1 AIR DEVICES

- A. Provide air devices of the minimum sizes and quantities indicated and of the types specified. Contractor shall carefully study the drawings and the field conditions to ascertain the air device requirements as to suitability, location, air capacity, required accessories, border and finish. Devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed Noise Criteria (NC) 25.
- B. Border types shall be compatible with Architectural ceiling type for the room for which the air device is located. All devices shall have plaster frames when installed in plaster or drywall construction.
- C. Margins shall be as indicated or directed to suit field conditions.
- D. Provide Titus, Kreuger, Price, Metalaire, Nailor or Tuttle & Bailey air devices in accordance with the schedule below and on the drawings.

E. Air Device Schedule:

Device	Type	Finish	Basis of Design
Ceiling Supply Diffuser	A	#26 white	Titus/TDCA
Ceiling Supply Diffuser	B	#26 white	Titus/TDC-AA
Return Register	C	#26 white	Titus/PAR

1. Type A: Ceiling diffusers shall be Titus Model TDCA (steel) or prior approved equal for adjustable discharge pattern. These diffusers shall consist of an outer frame assembly of the sizes and mounting types shown on the plans and outlet schedule. A square or rectangular inlet shall be an integral part of the frame assembly and a transition piece shall be available to facilitate attachment of round duct. An inner core assembly consisting of fixed deflection louvers shall be available in one-, two-, three- or four-way horizontal discharge patterns. Diffuser shall include adjustable vanes to provide full vertical projection as well as horizontal projection. The inner core assembly must be removable in the field without tools for easy installation, cleaning or damper adjustment.
  - a. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
  - b. Opposed blade volume damper shall not be provided. Throw Reducing Vanes (TRV) must be available to deflect a horizontal discharge airstream from each side of the TDC diffuser into diverging airstreams.
  - c. The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.
  
2. Type B: Ceiling diffusers shall be Titus Model TDC-AA (aluminum) or prior approved equal for fixed, horizontal discharge pattern. These diffusers shall consist of an outer frame assembly of the sizes and mounting types shown on the plans and outlet schedule. A square or rectangular inlet shall be an integral part of the frame assembly and a transition piece shall be available to facilitate attachment of round duct. An inner core assembly consisting of fixed deflection louvers shall be available in one-, two-, three- or four-way horizontal discharge patterns. The inner core assembly must be removable in the field without tools for easy installation, cleaning or damper adjustment.
  - a. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
  - b. Opposed blade volume damper shall not be provided. Throw Reducing Vanes (TRV) must be available to deflect a horizontal discharge airstream from each side of the TDC diffuser into diverging airstreams.
  - c. The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.



3. Type C: Perforated ceiling diffusers shall be Titus Model PAR (steel, flush face) or approved equal for return. Diffusers shall have a perforated face with 3/16-inch diameter holes on ¼-inch staggered centers and no less than 51 percent free area. Perforated face shall be steel. The backpan shall be one piece stamped heavy gauge steel of the sizes and mounting types shown on the plans and outlet schedule. The diffuser neck shall have 1 1/8-inch depth for easy duct connection. Diffusers must discharge a uniform horizontal blanket of air into the room and protect ceiling against smudging. Pattern controllers in the supply models shall be mounted on the back of the perforated face and must be field adjustable to allow the discharged air to enter the room in either vertical or one-, two-, three- or four-way horizontal jets. The perforated face must be easily unlatchable from the backpan to facilitate option of the face for pattern controller adjustment.
  - a. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
  - b. Opposed blade volume damper shall not be provided.
  - c. The manufacturer shall provide published performance data for the perforated diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

## 2.2 FIRE, FIRE/SMOKE, AND SMOKE DAMPERS

- A. Provide where indicated on the plans, fire dampers constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have 1-1/2 hour fire protection rating, 212 degrees Fahrenheit fusible link, and shall include a UL label in accordance with established UL labeling procedures and shall have Static Rating for HVAC systems that shut down automatically in a fire or smoke emergency or Dynamic Rating for HVAC systems that remain operational during a fire or smoke emergency. Three (3) hour dampers shall be installed where required by wall or floor rating. Damper Manufacturer's literature submitted for approval prior to installation shall include comprehensive performance data developed from testing in accordance with AMCA Standard 500 and shall illustrate pressure drops for all sizes or dampers required at all anticipated air flow rates. Fire dampers shall be equipped for vertical or horizontal installation as required by the locations indicated on the drawings. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles, other materials, and practices required to provide an installation equivalent to that utilized by the manufacturer when dampers were tested at UL. Fire damper installation shall also meet all requirements of the authority having jurisdiction. Installation shall be in accordance with the damper manufacturer's instructions. Fire dampers shall be Ruskin, Pottorff , United Enertech or approved equal to Ruskin Type IBD, DIBD, FD of the following styles:
  1. Low Pressure Rectangular Ducts - Style B.
  2. Low Pressure Round Ducts - Style CR.
  3. Medium Pressure Rectangular Ducts - Style C.
  4. Medium Pressure Round Ducts - Style CR.
  5. Medium Pressure Oval Ducts - Style CO.

6. Dampers for grilles, diffusers, registers, etc. - Thinline.
  - B. Fire damper assembly shall include fire damper and damper enclosure wall sleeve complete with duct attachment flanges, as detailed. Provide an access door at each fire damper located so as to permit easy maintenance of damper and fusible link. All fire dampers shall be installed in accordance with NFPA Requirements and the manufacturer's printed instructions.
  - C. Provide at locations shown on plans, combination fire/smoke dampers meeting or exceeding the following specifications. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, and shall further be classified by Underwriters Laboratories as Leakage Rated Damper for Use in Smoke Control Systems under the latest version of UL555S, and bear a UL label attesting to same and shall have Dynamic Rating. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be no higher than leakage Class I. Fire/Smoke dampers shall be Ruskin, Pottorff, United Enertech or approved equal to Ruskin Type FSD 37, FSD-60.
    1. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least four (4) inch water gauge in the closed position, and at least 2000 feet per minute air velocity in the open position. Pressures of at least six (6) inch or eight (8) inch water gauge shall have velocity levels of 3000 or 4000 feet per minute respectively.
    2. In addition to the leakage ratings already specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350 degrees Fahrenheit. Appropriate electric operators shall be installed by the damper manufacturer at time of damper fabrication; damper and operator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and operators.
    3. Each combination fire/smoke damper shall be equipped with a fusible link which shall melt at 212 degrees Fahrenheit causing damper to close and lock in a closed position. Damper shall be Ruskin Model FSD 37 or FSD60.
    4. Each combination fire/smoke damper shall be furnished with factory sleeve of length and gauge required for satisfactory installation, and with damper operator factory installed on exterior of sleeve and properly linked to damper operating shaft. Smoke dampers shall be provided with a pneumatic operator and be controlled under Division 23, Section "Automatic Temperature Controls".
    5. Operators shall be of the spring-return fail safe type that will close damper upon power interruption or control air failure. Damper operators shall be UL listed as Fire Damper Operators, and shall bear the appropriate UL Operator label.
    6. All wiring or piping material and labor required to interconnect the combination fire/smoke dampers with detection and/or control systems shall be under Division 23.
    7. Duct smoke detectors shall be supplied by Division 26 and installed under Division 23 in accordance with NFPA and the manufacturer's recommendations.
  - D. Provide at locations shown on plans smoke dampers similar to fire/smoke dampers specified hereinbefore equal to Ruskin, Pottorff United Enertech or approved equal to Ruskin Type SD60 and having a Dynamic Rating.
  - E. Submit samples for approval to the Architect of all fire, fire/smoke, and smoke damper

assemblies for low pressure and medium pressure duct systems. Dampers shall not be installed prior to receiving written approval of submitted samples.

- F. Fire, smoke and/or fire/smoke dampers in stainless steel duct systems shall be of stainless steel construction.

## 2.3 DUCTWORK

### A. General:

1. The Duct Manual as herein referenced shall mean the "HVAC Duct Construction Standards – Metal & Flexible", 3rd Edition, 2005 as published by the Sheet Metal and Air Conditioning Contractors National Association, Inc.
2. Unless noted otherwise, ductwork shall be constructed of prime, first quality galvanized steel of gauges as called for in the Duct Manual. Reinforce all ducts to prevent buckling, breathing, vibrations, or unnecessary noise. Such reinforcing shall be as recommended in Duct Manual, plus any additional reinforcing as required to meet job conditions. Longitudinal and cross joints, elbows, transitions, etc., shall be furnished as specified in Duct Manual, including recommended duct supports to suit job conditions.
3. All uninsulated rectangular ductwork shall be crossbroken on all four (4) sides of each panel section. All vertical and horizontal sheet metal barriers, duct offsets and elbows, as well as the panels of straight sections of ducts, shall be crossbroken. Crossbreaking shall be applied between the standing seams or reinforcing angles. The center of the crossbreak shall be of the required height to assure each panel section being rigid, to prevent vibrations and "breathing".
4. Ductwork and ductwork fittings for acid fume hood exhaust system shall be acid resistant fiberglass reinforced plastic ductwork.
5. Ductwork and ductwork fittings for fume hood, radio isotope, BL-3, glasswash, and tunnel/cagewash exhaust systems shall be fully welded type 304 stainless steel of gauges as called for in the Duct Manual.
6. Ductwork from kitchen exhaust hood to perimeter of kitchen shall be constructed of minimum 18 gauge stainless steel or 16 gauge black iron all welded construction with fully welded joints, and installed in accordance with the South Carolina State Health Department and the State Fire Marshals requirements. Kitchen hood exhaust ductwork from perimeter of kitchen to the exhaust fan shall be preengineered UL listed kitchen hood exhaust ductwork system with integral two (2) hour fire rating as specified herein. Provide access doors and fire rating around ductwork as required by code.
7. Dryer exhaust ductwork for clothes dryers shall terminate on the outside of the building with a hooded wall vent with integral backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct flow. Dryer exhaust shall be provided in accordance with the dryer manufacturers written instructions.
8. Supply air ductwork from air handling units to the air terminal units shall be "medium pressure" ductwork. Supply ductwork from air terminal units to air devices shall be "low pressure" ductwork.
9. Laboratory exhaust air ductwork shall be "medium pressure" ductwork.
10. Outdoor air, ventilation air, return air, relief air and non-laboratory exhaust air ductwork shall be low pressure ductwork.

11. Exposed circular low pressure supply ductwork shall be provided with grip finish and painted. Refer to Division 9 specifications. Color shall be by Architect.
12. Duct cleaning and acceptable level of contaminants allowed in the HVAC system, otherwise known as the Duct Cleanliness Level, shall be equal to Level C - Advanced in accordance with SMACNA Duct Cleanliness for New Construction, 2000 Edition.

**B. Low Pressure Ductwork (0" to 2" Water Gauge):**

1. Ductwork shall conform to requirements and details, unless specified or indicated otherwise in the SMACNA "HVAC Duct Construction Standards – Metal & Flexible", 3rd Edition, 2005. A copy of the duct manual shall be secured by the Contractor and shall be kept at the project for convenient reference.
2. Concealed circular low pressure supply and exhaust ductwork shall be United McGill low pressure spiral ductwork and fittings, equal to United Uni-seal spiral lockseam duct.
3. Exposed circular low pressure supply ductwork shall be acoustically insulated double-wall spiral ductwork and fittings. Double wall duct shall be constructed of a paintable outer shell, a 1" thick layer of fiberglass insulation and an inner metal liner. Insulation shall have a thermal conductivity "K" factor of .27 BTU/hr/sq. ft./°F or less. Double-wall spiral ductwork shall be United ACOUSTI-k27 spiral lockseam duct, Semco Industries SL95P, Lindab Safe, United Sheet Metal spiral pipe, or approved equal.
4. Flexible duct connections where indicated shall be "Ventglass" duct fabric as manufactured by Ventfabrics, Inc.
5. Low pressure ductwork shall conform to the requirements and details contained in the Duct Manual and shall be constructed to the requirements for two (2) inches water gauge. Construction shall conform to the following:
  - a. Material gauges (galvanized steel) & general construction - Tables 1-5, 1-10 thru 1-13 Seal Class B
  - b. Longitudinal seams - Fig. #1-5, Types L-1, L-3 & L-4
  - c. Corner Closures - Fig. #1-13 & # 1-14
  - d. Hangers - Fig. #4-1 & 4-4 & Tables 4-1 & 4-2
  - e. Radius Elbows - Fig. #2-2, Type RE-1 and RE-3
  - f. Vaned Elbows (Applied to Square elbows) - Fig. #2-2 Type Re-2 & Figs. #2-3 & #2-4, double thickness vanes only
  - g. Transitions & Offsets - Fig #2-9
  - h. Branch connections - Fig. #2-8, 45° only

- i. Volume dampers, up to 12" deep - Fig. #2-14, Figs. A&B w/Ventlok #555 quadrant
  - j. Volume dampers, over 12" deep - Fig. #2-15, Fig. A w/Ventlok #555 quadrant
  - k. Access doors - Cesco #HADDF-10 hinged one (1) side w/Ventlok #100 latch, insulated, one (1) inch thick
- 6. Duct sizes indicated on the drawings are air side sizes. Where duct lining is indicated, increase sheet metal sizes accordingly to compensate for thickness of lining.
  - 7. Seal all transverse joints in all low pressure supply ductwork with mineral impregnated woven fiber tape as manufactured by Hardcast, Inc.
  - 8. Provide stand-offs on volume dampers installed in all insulated ductwork.
  - 9. Flexible ductwork for connection to air devices shall be Casco Silent Flex II or FlexMaster Type 6B. Flexible duct shall have a minimum R-6 insulation, comply with NFPA Standard 90A and shall be U.L. listed as Class 1 Air Duct & Connector, Standard 181.

C. Medium Pressure Ductwork (Medium - Over 2" and up to 6" Water Gauge):

- 1. Medium pressure ductwork consists of rectangular, flat-oval, and circular types as indicated on the drawings.
- 2. Submit samples of medium pressure ductwork for approval as directed. Samples shall include longitudinal seams, transverse joints and reinforcement and others as requested. No ductwork shall be fabricated until duct construction samples are approved in writing by the Architect.
- 3. All medium pressure duct systems shall be leak tested in strict conformance with "HVAC Air Duct Leakage Test Manual", 1985. Tests shall be witnessed by the balance subcontractor as hereinafter specified.
- 4. Medium pressure ductwork shall conform to the requirements and details contained in the Duct Manual and shall be constructed to the requirements for six (6) inches water gauge. Construction shall conform to the following:
  - a. Reinforcement & Gauge - Tables #1-7, 1-10 thru 1-13
  - b. Transverse Joints - Figs. #1-4 Type T-21, #1-10, #1-12, #1-14, #1-15, Type T-21, and T-22, #1-16, #3-2 Type RT-1 and 2
  - c. Longitudinal Joints - Fig. #1-5 Type L-1 and L-3

- d. Vanes and Vane Runners - Fig. #2-3
- e. Branch Connections - Figs. #2-7 and 2-8
- f. Transitions - Figs #2-9
- g. Offsets - Figs. #2-9 Type 3
- h. Supporting Systems - Figs. #4-16, #4-17, #6-4, and Tables #4-1, #4-2 and #4-3
- i. Riser Supports - Fig. #4-6
- j. Volume and Floor - High Velocity Air Foil Type, Ultra-Low Leakage when closed, Ruskin CD-50 suitable for DDC operator provided under Division 23, Section "Automatic Temperature Controls".
- k. Supply and Exhaust Fan Isolation Dampers - High Velocity Air Foil Isolation Dampers Type, Ruskin OD102 fan outlet damper with silicone rubber blade seals, stainless steel jamb seals and bearings with integral shaft seals. Damper shall be suitable for DDC operator provided under Division 23, Section "Automatic Temperature Controls".
- l. Duct Sealants - See Section 1 Basic Duct Construction Duct Sealing Commentary
- m. Access Doors - CESCO #HADDF-10 with cam latches, neoprene gasketing and insulated, one (1) inch thick.
- n. Acoustical Liner - In conformance w/SMACNA Standard
- o. Welded Galvanized - Coated with two (2) coats of corrosion Resistant aluminum paint.

### PART 3 - EXECUTION

#### 3.1 AIR DEVICES

- A. Install air devices in accordance with the manufacturer's latest published installation instruction to insure against incorrect air pattern, drafts, and dirt smudging.
- B. Construct, and install sheet metal duct or plenum connections to air devices in accordance with terminal manufacturer's recommendations.
- C. Make modifications to the duct systems as required to accommodate actual sizes of air devices furnished, e.g., transformations and collar sizes without additional cost.
- D. Make joints between each devices and its components, connecting duct, or the mounting surface airtight, using gasket or its equivalent.
- E. Align exposed butt edges of linear diffusers using slots and keys strips or with other concealed means.

#### 3.2 DUCTWORK

- A. Install hangers, supports, and their attachments, generally in conformance with SMACNA standard referred to in this section of the specifications and applicable portions of article "Piping, Conduit and Supports", of Division 23, Section "Mechanical and Electrical General Provisions".
- B. Furnish hangers capable of withstanding five (5) times the weight of the load imposed on them without damage to duct or any adjacent construction.
- C. Neatly erect ducts and plenums of sizes and arrangements shown and detailed and as required to carry out intent of specifications and drawings. Work must meet approval of the Architect in all its parts and details.
- D. Sizes shown are air side sizes. Where ducts are shown as lined, dimensions shall be increased to reflect that thickness of the lining.
- E. Install ductwork in such a manner as to meet the recommendations of NFPA Standard 90A.
- F. Provide each air outlet with a collar adequately stiffened, fastened, and made suitable for securing air device thereto. Make field changes in ductwork, such as those required to accommodate the sizes of factory fabricated equipment actually furnished, i.e., coils, air filters, fans, damper and air terminal units and similar items, without additional cost. Provide duct flanges to match those of connecting factory fabricated equipment. When necessary, relocate and modify ductwork to avoid obstructions such as structural members, piping and conduit, in a manner acceptable to the (Architect/Engineer).
- G. Construct and install all ductwork in accordance with the SMACNA Standards specified.

Coordinate the installation of all duct systems with all other trades including plumbing, electrical, sprinkler, ceiling systems, etc.

- H. All open end return air ducts shall be provided with 1/2" galvanized wire mesh screen.
- I. Leak Testing of Ductwork:
  - 1. When deemed necessary by the Architect, test low pressure ductwork for leaks by sealing openings and pressurizing system to that static pressure which the system will operate. Use test methods approved by SMACNA and Architect. Seal all joints. Leakage shall not exceed three (3) percent of air flow specified at the system's nominal static pressure.
  - 2. Medium pressure ductwork shall be pressure tested as hereinbefore defined.
- J. Duct smoke detectors shall be installed where indicated on the electrical drawings. Duct smoke detectors shall be installed upstream of the associated smoke damper and within 6'-0" of the damper in as straight a section of ductwork as possible.

END OF SECTION 233110



## SECTION 238120 – HEATING AND AIR CONDITIONING EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes electric baseboard radiation heaters.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include details and dimensions of custom-fabricated enclosures.
  - 4. Indicate location and size of each field connection.
  - 5. Indicate location and arrangement of piping valves and specialties.
  - 6. Indicate location and arrangement of integral controls.
  - 7. Include enclosure joints, corner pieces, access doors, and other accessories.
  - 8. Include diagrams for power, signal, and control wiring.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Color Samples for Initial Selection: For heaters with factory-applied color finishes.
- E. Color Samples for Verification: For each type of exposed finish.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which radiation heaters will be attached.
2. Method of attaching radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

## PART 2 - PRODUCTS

### 2.1 ELECTRIC BASEBOARD RADIATION HEATERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  1. Cadet.
  2. Chromalox.
  3. Indeeco.
  4. Markel Products Company; TPI Corporation.
  5. Marley Engineered Products.
  6. Ouellet Canada Inc.
  7. Qmark; Marley Engineered Products.
- C. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
  1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
  1. Volts: 208
  2. Phase: Single
  3. Hertz: 60
  4. Heat Output: 250 W/ft
- E. Enclosures: Minimum 0.0329-inch thick steel, removable front cover.
  1. Full-height back.
  2. Full-length damper.
  3. End panel.
  4. End caps.

5. Inside and outside corners.
  6. Joiner pieces to snap together.
  7. Enclosure Height: 7.25 inches.
  8. Enclosure Depth: 2.875 inches.
  9. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
  10. Element Brackets: Primed and painted steel to support front panel and element.
- F. Rust-Resistant Enclosures: Minimum 0.040-inch thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
1. Full-height back.
  2. Full-length damper.
  3. End panel.
  4. End caps.
  5. Inside and outside corners.
  6. Joiner pieces to snap together.
  7. Enclosure Height: 7.25 inches.
  8. Enclosure Depth: 2.875 inches.
  9. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
  10. Element Brackets: Primed and painted steel to support front panel and element.
- G. Unit Controls: Remote line-voltage thermostat.
- H. Accessories:
1. Filler sections without a heating element matching the adjacent enclosure.
  2. Straight-blade-type receptacles complying with DSCC W-C-596G/GEN, NEMA WD 1, NEMA WD 6, and UL 498; in color selected by Architect.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas to receive radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before installation of finned-tube radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 ELECTRIC BASEBOARD RADIATION HEATER INSTALLATION

- A. Install units level and plumb.
- B. Install enclosure continuously around corners, using outside and inside corner fittings.

- C. Join sections with splice plates and filler pieces to provide continuous enclosure.
- D. Install enclosure continuously from wall to wall.
- E. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- F. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

### 3.3 CONNECTIONS

- A. Ground electric finned-tube radiation heaters according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 238120

## SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Building wires and cables rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.

#### 1.3 DEFINITIONS

- A. VFC: Variable frequency controller.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

### PART 2 - PRODUCTS

#### 2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Alcan Products Corporation; Alcan Cable Division.
  - 2. Alpha Wire.
  - 3. Belden Inc.
  - 4. Encore Wire Corporation.
  - 5. General Cable Technologies Corporation.
  - 6. Southwire Incorporated.

- B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2.
- D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

## 2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. AFC Cable Systems, Inc.
  - 2. Gardner Bender.
  - 3. Hubbell Power Systems, Inc.
  - 4. Ideal Industries, Inc.
  - 5. IlSCO; a branch of Bardes Corporation.
  - 6. NSi Industries LLC.
  - 7. O-Z/Gedney; a brand of the EGS Electrical Group.
  - 8. 3M; Electrical Markets Division.
  - 9. Tyco Electronics.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

## 2.3 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

## PART 3 - EXECUTION

### 3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible stranded.
- C. Wire size on 120 volt, 20 ampere branch circuit home run conductors over 75 feet in length (from closest wiring device at the home run designation to the associated panelboard shown on the electrical drawing sheets), shall be increase to No. 10 AWG (minimum) to limit excessive voltage drop.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.
- H. Each branch circuit shall have an individual neutral conductor. Increasing the neutral conductor size, or "super neutral," is not allowed for multiple branch circuits.
- I. Lighting Fixture Whips: Multi-conductor cable, Type MC with ground wire.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

### 3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material. Split bolt or crimp lugs only; no Polaris lugs.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

### 3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

### 3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260500 "Common Work Results for Electrical."

### 3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

### 3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
  - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- B. Test and Inspection Reports: Prepare a written report to record the following:
  - 1. Procedures used.
  - 2. Results that comply with requirements.
  - 3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.



- C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

## SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes: Grounding systems and equipment.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

#### 1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

### PART 2 - PRODUCTS

#### 2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
  - 1. Solid Conductors: ASTM B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Tinned Conductors: ASTM B 33.
  - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
  - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

## 2.2 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
  - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

## 2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in diameter.

## PART 3 - EXECUTION

### 3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
  - 1. Bury at least 24 inches below grade.
  - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
  - 3. Connections to Structural Steel: Welded connectors.

### 3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.

### 3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
  - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
  - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

### 3.4 FIELD QUALITY CONTROL

- A. Report measured ground resistances that exceed the following values:
  - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
  - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
- B. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

## SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Hangers and supports for electrical equipment and systems.
  - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
  - 1. Section 260548 "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

#### 1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

#### 1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

#### 1.5 ACTION SUBMITTALS

- A. Product Data: For the following:
  - 1. Steel slotted support systems.
  - 2. Nonmetallic slotted support systems.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Allied Tube & Conduit.
    - b. Cooper B-Line, Inc.; a division of Cooper Industries.
    - c. ERICO International Corporation.
    - d. GS Metals Corp.
    - e. Thomas & Betts Corporation.
    - f. Unistrut; Tyco International, Ltd.
    - g. Wesanco, Inc.
  2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
  3. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) Hilti Inc.
    - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
    - 3) MKT Fastening, LLC.
    - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
  
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
    - 2) Empire Tool and Manufacturing Co., Inc.
    - 3) Hilti Inc.
    - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
    - 5) MKT Fastening, LLC.
  
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

## 2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
  
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. **Maximum Support Spacing and Minimum Hanger Rod Size for Raceway:** Space supports for EMT, IMC, and RMC as required by IBC. Minimum rod size shall be 1/4 inch in diameter.
- C. **Multiple Raceways or Cables:** Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

### 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. **Raceway Support Methods:** In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. **Strength of Support Assemblies:** Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. **Mounting and Anchorage of Surface-Mounted Equipment and Components:** Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
  - 6. To Light Steel: Sheet metal screws.
  - 7. **Items Mounted on Hollow Walls and Nonstructural Building Surfaces:** Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes,



transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete.
- C. Anchor equipment to concrete base.
  - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION 260529

## SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

- 1. Metal conduits, tubing, and fittings.
- 2. Metal wireways and auxiliary gutters.
- 3. Boxes, enclosures, and cabinets.

- B. Related Requirements:

- 1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

#### 1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

B. Source quality-control reports.

## PART 2 - PRODUCTS

### 2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Anamet Electrical, Inc.
4. Electri-Flex Company.
5. O-Z/Gedney; a brand of EGS Electrical Group.
6. Picoma Industries, a subsidiary of Mueller Water Products, Inc.
7. Republic Conduit.
8. Robroy Industries.
9. Southwire Company.
10. Thomas & Betts Corporation.
11. Western Tube and Conduit Corporation.
12. Wheatland Tube Company; a division of John Maneely Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. FMC: Comply with UL 1; zinc-coated steel.

H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Fittings for EMT:

- a. Material: Steel.
  - b. Type: compression.
2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
  3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- J. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.2 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Adalet.
  2. Cooper Technologies Company; Cooper Crouse-Hinds.
  3. EGS/Appleton Electric.
  4. Erickson Electrical Equipment Company.
  5. FSR Inc.
  6. Hoffman; a Pentair company.
  7. Hubbell Incorporated; Killark Division.
  8. Kraloy.
  9. Milbank Manufacturing Co.
  10. Mono-Systems, Inc.
  11. O-Z/Gedney; a brand of EGS Electrical Group.
  12. RACO; a Hubbell Company.
  13. Robroy Industries.
  14. Spring City Electrical Manufacturing Company.
  15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
  16. Thomas & Betts Corporation.
  17. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- J. Gangable boxes are prohibited.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures: Plastic.
  - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

### PART 3 - EXECUTION

#### 3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
  - 1. Exposed Conduit: EMT.
  - 2. Concealed Conduit, Aboveground: EMT.
  - 3. Concealed Conduit, Aboveground within concrete beams and columns: RNC, Type EPC-40-PVC with rigid steel conduit elbows.
  - 4. Concealed Conduit, In concrete slab: RNC, Type EPC-40-PVC with rigid steel conduit elbows.
  - 5. Underground Conduit: See specification 260543.
  - 6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 7. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
  - 1. Exposed, Not Subject to Physical Damage: EMT.
  - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
  - 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
  - 5. Damp or Wet Locations: EMT.
- C. Minimum Raceway Size: 3/4-inch trade size.

- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
  - 3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
  - 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

### 3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Stub-ups to Above Recessed Ceilings:
  - 1. Use EMT, IMC, or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- M. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- O. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- P. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- Q. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- R. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
  1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  2. Where an underground service raceway enters a building or structure.
  3. Where otherwise required by NFPA 70.
- S. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- T. Expansion-Joint Fittings:
  1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental

- temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    - d. Attics: 135 deg F temperature change.
  3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
  4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
  5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- U. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
  2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- V. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.
- W. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- X. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- Y. Locate boxes so that cover or plate will not span different building finishes.
- Z. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- AA. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.



BB. Set metal floor boxes level and flush with finished floor surface.

CC. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

### 3.3 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

## SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

- 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
- 2. Sleeve-seal systems.
- 3. Sleeve-seal fittings.
- 4. Grout.
- 5. Silicone sealants.

- B. Related Requirements:

- 1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. LEED Submittals:

- 1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

#### 1.4 SLEEVES

- A. Wall Sleeves:

- 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized sheet steel.
  - 2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

#### 1.5 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Advance Products & Systems, Inc.
    - b. CALPICO, Inc.
    - c. Metraflex Company (The).
    - d. Pipeline Seal and Insulator, Inc.
    - e. Proco Products, Inc.
  - 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 3. Pressure Plates: Carbon steel.
  - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

#### 1.6 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. Presealed Systems.

#### 1.7 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

#### 1.8 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
  2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

### PART 2 - EXECUTION

#### 2.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

- a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
  - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
  4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.
- 2.2 SLEEVE-SEAL-SYSTEM INSTALLATION
- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

2.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

## SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

- B. Related Sections include the following:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

#### 1.3 DEFINITIONS

- A. The IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

#### 1.4 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
  1. See Structural Code Sheet.

#### 1.5 ACTION SUBMITTALS

- A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
  2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
    - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
    - b. Annotate to indicate application of each product submitted and compliance with requirements.
  3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
- B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
    - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.
  2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
  3. Field-fabricated supports.
  4. Seismic-Restraint Details:
    - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    - c. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

#### 1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- B. Qualification Data: For professional engineer.



- C. Welding certificates.
- D. Field quality-control test reports.

#### 1.7 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- D. Comply with NFPA 70.

### PART 2 - PRODUCTS

#### 2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ace Mountings Co., Inc.
  - 2. Amber/Booth Company, Inc.
  - 3. California Dynamics Corporation.
  - 4. Isolation Technology, Inc.
  - 5. Kinetics Noise Control.
  - 6. Mason Industries.
  - 7. Vibration Eliminator Co., Inc.
  - 8. Vibration Isolation.
  - 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
  - 1. Resilient Material: Oil- and water-resistant neoprene.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the 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, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

## 2.2 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
  2. California Dynamics Corporation.
  3. Cooper B-Line, Inc.; a division of Cooper Industries.
  4. Hilti Inc.
  5. Loos & Co.; Seismic Earthquake Division.
  6. Mason Industries.
  7. TOLCO Incorporated; a brand of NIBCO INC.
  8. Unistrut; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

## 2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
  - 1. Powder coating on springs and housings.
  - 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
  - 3. Baked enamel or powder coat for metal components on isolators for interior use.
  - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

### 3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment and Hanger Restraints:
  - 1. Install restrained isolators on electrical equipment.
  - 2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
  - 3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.
- B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- D. Drilled-in Anchors:
  - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
  - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
  - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
  - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
  - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
  - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

### 3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
  - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
  - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
  - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
  - 5. Test to 90 percent of rated proof load of device.
  - 6. Measure isolator restraint clearance.
  - 7. Measure isolator deflection.
  - 8. Verify snubber minimum clearances.
  - 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

### 3.6 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

## SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Identification for raceways.
  - 2. Identification of power and control cables.
  - 3. Identification for conductors.
  - 4. Underground-line warning tape.
  - 5. Warning labels and signs.
  - 6. Instruction signs.
  - 7. Equipment identification labels.
  - 8. Miscellaneous identification products.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

#### 1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

#### 1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's

wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

## PART 2 - PRODUCTS

### 2.1 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
  - 1. Black letters on an orange field.
  - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING."
- D. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
- E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.
- H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

- I. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
  1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
  2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

## 2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Colors for Cables Carrying Circuits at 600 V and Less:
  1. Black letters on an orange field.
  2. Legend: Indicate voltage and system or service type.
- C. Colors for Cables Carrying Circuits at More Than 600 V:
  1. Black letters on an orange field.
  2. Legend: "DANGER HIGH VOLTAGE WIRING."
- D. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
- E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.
- F. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tube with machine-printed identification label. Sized to suit diameter of and shrinks to fit firmly around cable it identifies. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.

## 2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
- C. Self-Adhesive, Self-Laminating Polyester Labels: Write-on, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the cable diameter such that the clear shield overlaps the entire printed legend.



- D. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tube with machine-printed identification label. Sized to suit diameter of and shrinks to fit firmly around cable it identifies. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.
- E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
- F. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
  - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
  - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- G. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.
- H. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

#### 2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Self-Adhesive, Self-Laminating Polyester Labels: Write-on, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.
- E. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tube with machine-printed identification label. Sized to suit diameter of and shrinks to fit firmly around conductor it identifies. Full shrink recovery at a maximum of 200 deg F. Comply with UL 224.
- F. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- G. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Labels for Tags: Self-adhesive label, machine-printed with permanent, waterproof, black ink recommended by printer manufacturer, sized for attachment to tag.

## 2.5 UNDERGROUND-LINE WARNING TAPE

### A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

### B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE,.

## 2.6 WARNING LABELS AND SIGNS

### A. Comply with NFPA 70 and 29 CFR 1910.145.

### B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

### C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

### D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

## 2.7 INSTRUCTION SIGNS

### A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

## 2.8 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

## 2.9 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

## 2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.
- G. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- I. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
  - 1. Outdoors: UV-stabilized nylon.
  - 2. In Spaces Handling Environmental Air: Plenum rated.
- J. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

### 3.2 IDENTIFICATION SCHEDULE

- A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
  2. Wall surfaces directly external to raceways concealed within wall.
  3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.
- D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service and feeder conductors.
    - a. Color shall be factory applied[ or field applied for sizes larger than No. 8 AWG.
    - b. Colors for 208/120-V Circuits:
      - 1) Phase A: Black.
      - 2) Phase B: Red.
      - 3) Phase C: Blue.
    - c. Colors for 480/277-V Circuits:
      - 1) Phase A: Brown.
      - 2) Phase B: Orange.
      - 3) Phase C: Yellow.
    - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- E. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags.

- F. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.
- H. Control-Circuit Conductor Termination Identification: For identification at terminations provide self-adhesive vinyl labels with the conductor designation.
- I. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- K. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
  - 1. Limit use of underground-line warning tape to direct-buried cables.
  - 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- L. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
  - 1. Comply with 29 CFR 1910.145.
  - 2. Identify system voltage with black letters on an orange background.
  - 3. Apply to exterior of door, cover, or other access.
  - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
    - a. Power transfer switches.
    - b. Controls with external control power connections.
- N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual.

Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:
  - a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
  - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
  - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
  - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
  
2. Equipment to Be Labeled:
  - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
  - b. Enclosures and electrical cabinets.
  - c. Access doors and panels for concealed electrical items.
  - d. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
  - e. Enclosed switches.
  - f. Enclosed circuit breakers.
  - g. Enclosed controllers.
  - h. Variable-speed controllers.
  - i. Automatic Transfer Switches.

END OF SECTION 260553

## SECTION 262416 - PANELBOARDS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Distribution panelboards.
  - 2. Lighting and appliance branch-circuit panelboards.

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
  - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 6. Include wiring diagrams for power, signal, and control wiring.



#### 1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems." Include the following:
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Field Quality-Control Reports:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Panelboard Schedules: For installation in panelboards.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

#### 1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.

- E. Comply with NFPA 70.

#### 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panelboards for installation according to NEMA PB 1.

#### 1.9 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

#### 1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Five years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

- B. Enclosures: Flush- and surface-mounted cabinets.

- 1. Rated for environmental conditions at installed location.

- a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
- b. Outdoor Locations: NEMA 250, Type 3R.

- 2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

- 3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

- 4. Finishes:

- a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

- b. Back Boxes: Galvanized steel.
- 5. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Incoming Mains Location: Top or bottom as required.
- D. Phase, Neutral, and Ground Buses:
  - 1. Material: Hard-drawn copper, 98 percent conductivity.
  - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
  - 1. Material: Hard-drawn copper, 98 percent conductivity.
  - 2. Main and Neutral Lugs: Compression type.
  - 3. Ground Lugs and Bus-Configured Terminators: Compression type.
  - 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

## 2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- D. Mains: Circuit breaker and Lugs only.

- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

## 2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: As indicated on panel schedules.
- D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

## 2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D; a brand of Schneider Electric.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 2. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
    - a. Standard frame sizes, trip ratings, and number of poles.

- b. Lugs: compression style, suitable for number, size, trip ratings, and conductor materials.
- c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install filler plates in unused spaces.
- F. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- H. Comply with NECA 1.

### 3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- C. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

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Architect's Project No. 12.130.03  
University Project No. H27-1998-A  
04/08/13  
**04/10/13**

END OF SECTION 262416

## SECTION 262726 - WIRING DEVICES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
  - 2. Weather-resistant receptacles.
  - 3. Twist-locking receptacles.
  - 4. Snap switches.
  - 5. Floor service outlets.

#### 1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.



## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
  - 1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
  - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
  - 3. Leviton Mfg. Company Inc. (Leviton).
  - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

### 2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
  - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
  - 2. Devices shall comply with the requirements in this Section.

### 2.3 STRAIGHT-BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Cooper; 5351 (single), CR5362 (duplex).
    - b. Hubbell; HBL5351 (single), HBL5352 (duplex).
    - c. Leviton; 5891 (single), 5352 (duplex).
    - d. Pass & Seymour; 5361 (single), 5362 (duplex).

## 2.4 GFCI RECEPTACLES

### A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

### B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Cooper; VGF20.
  - b. Hubbell; GFR5352L.
  - c. Pass & Seymour; 2095.
  - d. Leviton; 7590.

## 2.5 TWIST-LOCKING RECEPTACLES

### A. Single Convenience Receptacles, 250 V, 30 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L6-30R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Cooper; CWL520R.
  - b. Hubbell; HBL2310.
  - c. Leviton; 2310.
  - d. Pass & Seymour; L520-R.

## 2.6 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, die-cast aluminum with satin finish suitable for installation in synthetic turf for the batting cage.
- D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: Blank cover with bushed cable opening.

## 2.7 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

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

1) Single Pole:

- a) Cooper; AH1221.
- b) Hubbell; HBL1221.
- c) Leviton; 1221-2.
- d) Pass & Seymour; CSB20AC1.

2) Three Way:

- a) Cooper; AH1223.
- b) Hubbell; HBL1223.
- c) Leviton; 1223-2.
- d) Pass & Seymour; CSB20AC3.

3) Four Way:

- a) Cooper; AH1224.
- b) Hubbell; HBL1224.
- c) Leviton; 1224-2.
- d) Pass & Seymour; CSB20AC4.

2.8 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

- 1. Plate-Securing Screws: Metal with head color to match plate finish.
- 2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
- 3. Material for Unfinished Spaces: Galvanized steel.

B. Wet-Location, Weatherproof "While in Use" cover: NEMA 250, complying with Type 3R, weather-resistant, non-metallic grey with solid grey non-metallic cover (no clear cover).

2.9 FINISHES

A. Device Color:

- 1. Wiring Devices Connected to Normal Power System: grey unless otherwise indicated or required by NFPA 70 or device listing.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
  - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
  - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
  - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
  - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- D. Device Installation:
  - 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
  - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
  - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
  - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
  - 6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
  - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
  - 8. Tighten unused terminal screws on the device.
  - 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

### 3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

### 3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Provide panel name and circuit number on all devices including the baseboard heaters.

### 3.4 FIELD QUALITY CONTROL

A. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

B. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

## SECTION 265100 - INTERIOR LIGHTING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Interior lighting fixtures, lamps, and ballasts.
  - 2. Exit signs.
  - 3. Lighting fixture supports.
  - 4. Indoor occupancy sensors.
  - 5. Emergency Shunt Relays.

#### 1.3 DEFINITIONS

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting fixture, including ballast housing if provided.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
  - 1. Physical description of lighting fixture including dimensions.
  - 2. Ballast, including BF.
  - 3. Energy-efficiency data.

4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps including mercury content.
5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

B. Shop Drawings: Show installation details for occupancy sensors.

1. Interconnection diagrams showing field-installed wiring.
2. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.8 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Lighting Unit Batteries: 1 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
2. Warranty Period for Emergency Fluorescent Ballast Batteries: one year from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide product indicated on the Lighting Fixture Schedule on the Drawings.

### 2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- C. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- D. Metal Parts: Free of burrs and sharp corners and edges.
- E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- G. Diffusers and Globes:
  - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    - a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
    - b. UV stabilized.
  - 2. Glass: Annealed crystal glass unless otherwise indicated.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
  - 1. Label shall include the following lamp and ballast characteristics:
    - a. "USE ONLY" and include specific lamp type.
    - b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.



- c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
- d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
- e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
- f. CCT and CRI for all luminaires.

## 2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

### A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.
2. Designed for type and quantity of lamps served.
3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
4. Sound Rating: Class A.
5. Total Harmonic Distortion Rating: Less than 10 percent.
6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
7. BF: 0.88 or higher.
8. Power Factor: 0.95 or higher.
9. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
10. Temperatures 0 Deg F and Higher: Electronic type rated for 0 deg F starting and operating temperature with indicated lamp types.

### B. Luminaires controlled by occupancy sensors shall have programmed-start ballasts.

### C. Electronic Programmed-Start Ballasts for T8 Lamps: Comply with ANSI C82.11 and the following:

1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
2. Automatic lamp starting after lamp replacement.

## 2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

### A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: Class A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
6. Operating Frequency: 20 kHz or higher.

7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher unless otherwise indicated.
9. Power Factor: 0.95 or higher.
10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

## 2.5 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
  1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

## 2.6 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 25 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours unless otherwise indicated.
- B. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at three hours operation per start, and suitable for use with dimming ballasts unless otherwise indicated.
  1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
  2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
  3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
  4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
  5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
  6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
  7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

## 2.7 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

- E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

## 2.8 INDOOR OCCUPANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Mfg. Company Inc.
4. Lightolier Controls.
5. Lithonia Lighting; Acuity Lighting Group, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC; TORK Products.
8. Sensor Switch, Inc.
9. Square D; a brand of Schneider Electric.
10. Watt Stopper.

- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
5. Mounting:
  - a. Sensor: Suitable for mounting in any position on a standard outlet box.
  - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
  - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
7. Bypass Switch: Override the "on" function in case of sensor failure.
8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

- C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

## 2.9 EMERGENCY SHUNT RELAY (UL924 Relay)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Lighting Control and Design; Acuity Lighting Group, Inc.
  2. Watt Stopper.
- B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
  1. Coil Rating: 277 V.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Lighting fixtures:
  1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
  2. Install lamps in each luminaire.
- B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
- C. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
  1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.
  2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
  3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

D. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.2 SENSOR INSTALLATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

### 3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.4 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 265100

## SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Fire-alarm control unit.
  - 2. System smoke detectors.
  - 3. Notification appliances.
  - 4. Addressable interface device.

#### 1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. NICET: National Institute for Certification in Engineering Technologies.

#### 1.4 SYSTEM DESCRIPTION

- A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

#### 1.5 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### 1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

- B. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
1. Comply with recommendations in the "Documentation" Section of the "Fundamentals" Chapter in NFPA 72.
  2. Include voltage drop calculations for notification appliance circuits.
  3. Include battery-size calculations.
  4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
  5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
- C. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
  2. Shop Drawings shall be prepared by persons with the following qualifications:
    - a. Trained and certified by manufacturer in fire-alarm system design.
    - b. NICET-certified fire-alarm technician, Level III minimum.
    - c. Licensed or certified by authorities having jurisdiction.
- D. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
  2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

## 1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.



3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

## 1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," deliver copies to authorities having jurisdiction and include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide **documents** according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
  - a. Frequency of testing of installed components.
  - b. Frequency of inspection of installed components.
  - c. Requirements and recommendations related to results of maintenance.
  - d. Manufacturer's user training manuals.
5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

## 1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

#### 1.10 PROJECT CONDITIONS

- A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
  - 1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
  - 2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

#### 1.11 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

#### 1.12 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
  - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

#### 1.13 PROGRAMMING

- A. Coordinate room numbering with the Owner prior to programming the fire alarm system. Room numbers are not necessarily the ones shown on contract documents.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Gamewell-FCI, Fire Control Instruments.

### 2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. System operation shall match existing.

### 2.3 FIRE-ALARM CONTROL UNIT

- A. The existing fire alarm control panel is model FCI 7100 and is existing to remain. Modify as required to accommodate the renovation. Provide a new FCI 7100 and network card in existing cabinet to make a fully functional and communicating fire alarm system between the old and new units.
- B. Circuits:
1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.
    - a. Match existing class and type.
    - b. Install no more than 50 addressable devices on each signaling line circuit.
  2. All fire alarm circuits shall be installed in raceway. See Section 260533 "Raceways and Boxes for Electrical Systems" for installation details.
- C. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
  2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
  3. Sound general alarm if the alarm is verified.
  4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- D. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

- E. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
  - 1. Batteries: Sealed lead calcium. Modify as necessary to accommodate new devices.
- F. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

## 2.4 SYSTEM SMOKE DETECTORS

### A. General Requirements for System Smoke Detectors:

- 1. Comply with UL 268; operating at 24-V dc, nominal.
- 2. Detectors shall be two-wire type.
- 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- 4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
- 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
- 6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

### B. Photoelectric Smoke Detectors:

- 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
- 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).

### C. Ionization Smoke Detector:

- 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
- 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.

- c. Present average value.
- d. Present sensitivity selected.
- e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.5 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
  1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
- A. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet** from the horn, using the coded signal prescribed in UL 464 test protocol.
- B. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.
  1. Rated Light Output:
    - a. 15/30/75/110 cd, selectable in the field.
  2. Mounting: Ceiling mounted unless otherwise indicated.

3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, white.

## 2.6 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.
- C. Secondary Power: Integral rechargeable battery and automatic charger.
- D. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

## PART 3 - EXECUTION

### 3.1 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
  1. Connect new equipment to existing control panel in existing part of the building.
  2. Connect new equipment to existing monitoring equipment at the supervising station.
  3. Expand, modify, and supplement existing control equipment as necessary to extend existing control functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- C. Smoke- or Heat-Detector Spacing:
  1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
  2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
  3. Smooth ceiling spacing shall not exceed 30 feet.
  4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
  5. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
  6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

- D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

### 3.2 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
  - 1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
  - 1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
  - 2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
  - 3. Smoke dampers in air ducts of designated air-conditioning duct systems.

### 3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

### 3.4 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

### 3.5 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
  - a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
  - b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

### 3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111