Alvine

CONSTRUCTION DOCUMENTS

CITY OF HASTINGS NORTH DENVER STATION
CONTROL ROOM HVAC REPLACEMENT

Hastings, Nebraska

2024 1598

September 5, 2025

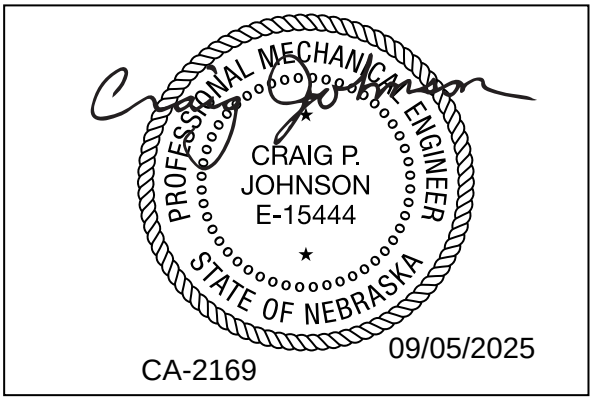
Project Specifications
Construction Documents

Alvine Engineering

City of Hastings North Denver Station Control Room HVAC Replacement

Hastings, Nebraska

Alvine No. 2024 1598



September 5, 2025

09/05/2025
I, Craig Johnson, am the Coordinating Professional for the City of Hastings North Denver Station Control Room HVAC Replacement project.

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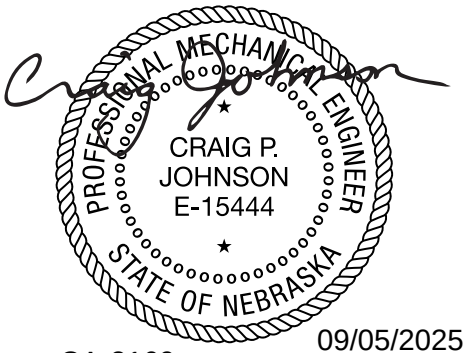


09/05/2025

CA-2169

SECTION 23 04 00

COMMON REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes basic materials and methods to complement other Division 23 Sections.

1.2 WARRANTIES

A. Warrant all materials, workmanship and equipment against defects for a period of one year after the date of substantial completion.

B. Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those divisions of the Project Manual.

C. Repair or replace, at no additional cost to the Owner, any item which may become defective within the warrant period.
   1. Repair or replacement of compressorized equipment shall include a complete refrigerant charge.

D. Any manufacturers' warranties concerning any item installed will run to the benefit of the Owner.

E. The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project.

F. The repair of faulty workmanship shall be considered to be included in the contract.

1.3 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Engineer for clarification.

B. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date.

C. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.

D. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

E. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.4 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, request clarification from the Engineer before proceeding with the work.

B. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Engineer.

C. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Engineer was requested and obtained before submission of proposed methods or materials.

D. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 DEFINITIONS

A. The following definitions shall apply throughout the contract documents:
1. Engineer: Architect or Engineer
2. Code: All applicable national, state and local code
3. Mechanical: All plumbing, HVAC, & fire protection work required by the Contract Documents
4. Electrical: All electrical and fire alarm work required by the Contract Documents
5. Contractor: Any Contractor performing work required by the Contract Documents
6. Indicated: Shown on drawings, noted, scheduled or specified
7. Selected: Selected by the Architect or Engineer
8. Provide: Furnish, install, connect and tested complete and ready for use
9. Furnish: Supply and deliver to the site ready for installation
10. Install: Install complete, per Contract Documents and manufacturer's requirements.
11. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
12. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
13. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
14. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
15. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
16. Dry Locations: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

17. Damp Locations: Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.
    a. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.
18. Wet Locations: Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

1.6 SYMBOLS

A. Items of equipment and materials are indicated on the drawings in accordance with the symbols shown on the plans.

1.7 ABBREVIATIONS

A. Refer to abbreviations list shown on the Drawings.

1.8 CODES

A. The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.

B. All work shall conform to all applicable sections of currently adopted editions of the following codes, standards, and specifications:
1. International Building Code (IBC)
2. International Fire Code (IFC)
3. International Energy Conservation Code (IECC)
4. International Fuel Gas Code (IFGC)
5. Uniform Plumbing Code(UPC)
6. International Mechanical Code (IMC)
7. Safety and Health Regulations for Construction
8. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
9. National Electrical Code (NEC)
10. National Fire Protection Association (NFPA)
11. Life Safety Code (NFPA 101)
12. American Gas Association (AGA)
13. Underwriters' Laboratories, Inc. (UL)
14. National Electrical Safety Code (NESC)
15. All applicable national, state and local codes and amendments.

1.9 PERMITS

A. The Contractors shall familiarize themselves with all requirements regarding all permits, fees, etc., and shall comply with them.

B. All permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.

C. All utilities shall be installed in accordance with the local rules and regulations and all charges shall be paid by the Contractor.

1.10 CODE COMPLIANCE

A. Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that indicated shall not be substituted.

B. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of systems. Wherever practical, install systems as indicated.

C. Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

1.11 MATERIALS AND EQUIPMENT MANUFACTURERS

A. Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.

B. Materials and equipment shall be provided in accordance with the following:
   1. Primary Design Products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
   2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.
   3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
   4. Acceptable Equivalent Substitutions: Acceptable equivalent substitutions are products of manufactures other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:
      a. The product shall be manufactured by one of the acceptable manufacturers listed in the Project Manual, drawings, or addenda.
      b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
      c. The Contractor providing the substitution shall bear the total cost of all changes due to substitutions. These costs may include additional compensation to the Engineer for redesign and evaluation services,

increased cost of work by the Owner or other Contractors, and similar considerations.

d. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.

e. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.

f. Proposed substitutions will be judged on the basis of quality, performance, appearance and on the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.

g. The Engineer shall be the sole and final judge as to the suitability of substitution items.

1.12 SUBMITTALS

A. Shop Drawings, Product Data and Samples:

1. Other section in the Project Manual shall be adhered to if more stringent than the following paragraphs.
2. When required by other sections of this Project Manual, submit shop drawings, product data or samples to the Engineer for review.
3. Submittals deemed unnecessary by the Engineer shall be returned indicating “No Action Taken”.
4. A completed copy of the transmittal form included with the Project Manual shall accompany each submittal.
5. Submittals shall be labeled indicating the specification number and title, shop drawing or product data description and the respective Part 2 paragraph and sub-paragraph numbers.
6. Submittals not listed in the Project manual shall reference the respective contract document.
7. Unless otherwise noted, submit one copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
   a. Shop drawings and product data shall be in original searchable PDF format.
8. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor to illustrate some portion of the work. Shop Drawings shall also detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.
   a. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.
9. Product data are illustrations, standard schedules, performance charts, instruction brochures, diagrams and other information furnished by the

Contractor, Manufacturer, Supplier, or Distributor to illustrate a material, product or system for some portion of the work.

10. All submittals shall clearly indicate proposed items, capacities, characteristics and details in conformance with contract documents. All equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions and special features required shall be certified by the manufacturer.
11. Submittals shall indicate manufacturer's delivery time for the item after review by the Engineer.
12. The Engineer shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
13. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Engineer's review of shop drawings, product data or samples.
14. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Engineer's review of those drawings.

B. Operation and Maintenance Manuals:
   1. Prepare electronic operation and maintenance manuals for the equipment furnished.
   2. The manual shall be in original searchable PDF format with equipment organized by specification section. Bookmarking shall be provided in the PDF for each specification section and piece of equipment.
   3. Manuals shall be submitted to the Engineer for review and distribution to the Owner not less than 30 days prior to substantial completion of the project.
   4. Manuals not meeting the requirements of this section may be rejected by the Engineer.
   5. Manual shall include, but shall not be limited to, the following:
      a. A cover page including:
         1) Project name and address
         2) Division of work covered by the manual
         3) Name, address and telephone number of Contractor and all Sub-Contractors including night or emergency numbers
      b. A Complete Index. Contractor may submit the index to the Engineer for review prior to submittal of complete manuals if desired.
      c. Manufacturer's equipment product data O&M manuals and parts lists identified by the equipment mark used in the contract drawings.
      d. Names, Addresses and Telephone Numbers. This list shall include the manufacturer and local representative who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the manual.
      e. Startup, Operation and Shutdown Procedures. Provide a written description of procedures for startup, operation and shutdown of each item or system. This description shall include motors to start, valves to open, etc., in proper sequence, and the location of switches, starters, pushbuttons and valves. Description shall include item references or

labels used in the contract documents unless otherwise instructed in advance by the Owner.

f. Seasonal Changeover Procedure. Provide a written description of the procedure for necessary seasonable changeover from heating to cooling and vice versa.

g. Equipment Accessory Schedule. Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required and the manufacturer of all renewable items.

h. Lubrication Schedule. Provide a chart listing each piece of equipment, the proper type of oil or grease required, and recommended frequency of lubrication.

i. Emergency Procedures. Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.

j. One copy of all shop drawings.

k. Signed letters of certification of inspection and similar information.

l. All manufacturers' warranty information.

m. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner’s representative(s) present, date and time of training.

n. Normal Maintenance Schedule. Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days and yearly.

o. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.

p. Motor List. The list shall indicate motor location, equipment served (using labels indicated on drawings), horsepower, electrical characteristics, motor type, and rpm. Motors less than 1/2 horsepower need not be included.

1.13 OPERATING TRAINING

A. Complete operating instructions for each system and item of equipment shall be provided to the Owner's designated personnel.

B. Operation and Maintenance Manuals must be reviewed and accepted by the Engineer and provided to the Owner prior to operating training.

C. Training shall be scheduled at the convenience of the Owner. A minimum of 4 hours, per system, of training shall be provided.

D. Training shall include instructions on the following:

1. Startup and shutdown procedures
2. Seasonal changeover
3. Periodic maintenance
4. Emergency operation
5. Safety

E. In addition to the instructions required above, wherever possible perform the operations being described in order to fully illustrate system operation.

F. At the completion of training, turn over to the Owner all required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.

1.14 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, “Structural Welding Code-Steel”.

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

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.15 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.16 COORDINATION

A. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of systems. Wherever practical, install systems as indicated.

B. Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.

C. Arrange for spaces, chases, slots, and openings in building structure during progress of construction to allow for system installations.

D. Coordinate arrangement, mounting, and support of equipment.
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.

E. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the installations that follow.
   1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

F. Sequence, coordinate, and integrate installing materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

G. Coordinate service connections to components furnished by utility companies.
   1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for metering components.
   2. Comply with requirements of authorities having jurisdiction and of utility company providing water, gas, electrical power and other services.

H. Coordinate location of access panels and doors for items that are concealed by finished surfaces.

I. Coordinate testing of items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.17 STRUCTURAL COORDINATION

A. In cases where the Contractor determines that superimposed loads such as suspended or floor mounted mechanical, electrical, plumbing system or equipment exist which exceed design loads indicated on structural contract documents, Contractor shall submit load data to Design Professionals for review prior to proceeding with work.

B. Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc. over the member’s tributary area in a way that the design superimposed dead loads listed in structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.

C. Connections of systems designed by Contractor’s engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for designing, furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

D. Coordinate locations of new fire suppression, plumbing and HVAC penetrations through existing structure and construction. Utilize all existing documentation of conditions for coordination. Verify penetrations utilizing GPR (Ground Penetrating Radar) as necessary to confirm penetration locations.

PART 2 - PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Specific Notes and/or Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 SHORT-CIRCUIT CURRENT RATING (SCCR) FOR EQUIPMENT AND ASSOCIATED CONTROL PANELS

A. SCCR Compliance - Equipment manufacturers and suppliers shall provide a certified SCCR for all equipment and associated panels to be provided with equipment procured under these specifications. The certified SCCR rating shall be no less than the value of the available fault current at the switchboard or panel serving the equipment as indicated on the Division 26 Electrical Riser Diagrams. Manufacturer shall provide internal components that meet or exceed the SCCR rating required by these specifications. Manufacturer shall refer to the National Electrical Code (NEC), which is also known as NFPA 70, Article 100 for additional requirements

B. Supplemental SCCR Compliance Data - At the manufactures option, they may calculate the available fault current at the specific equipment connection point. Manufacturer shall obtain feeder size, breaker type and length of feeder from the Division 26 contractor. All calculations shall be submitted as part of the equipment submittal for review by the engineer.

C. Application of Labels - All equipment and control panels associated with equipment procured under these specifications shall have a permanently installed label provided by the manufacturer as a part of the equipment indicating the SCCR rating of the equipment. Labels shall comply with NEC Article 409 - Industrial Control Panels, and NEC Article 670 - Industrial Machinery.

2.3 MATERIALS

A. Unless otherwise specified, all materials and equipment shall be new, unused and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production.

2.4 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

A. Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.5 QUANTITY OF SPECIFIED ITEMS REQUIRED

A. Wherever in these specifications an article, device or piece of equipment is referred to in the singular number; such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.6 ROOF MOUNTED PIPE, DUCTWORK AND CONDUIT SUPPORT SYSTEMS

A. Manufactures:
   1. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.
   2. Eaton, Dura-Blok.
   3. Erico International Corporation: www.erico.com.
   4. PHP Systems/Design, www.phpsd.com
   5. Unistrut, UNIpier.

B. Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
   1. Bases: UV resistant material, molded polycarbonate resin, HDPE or rubber.
   2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
   3. Stut style, galvanized steel horizontal and vertical supports, attaching hardware.
   4. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
   5. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
   6. Height: Provide minimum clearance of 18 inches under pipe to top of roofing.
      a. Adjustable mounting height.
   7. Operating temperature: -30F to 150F.

2.7 ELECTRICAL WIRE

A. All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.

B. All wiring running exposed in return air plenums shall be plenum-rated cable for fire and smoke spread.

2.8 LOW VOLTAGE CONTROL WIRE AND CABLE

A. All wiring materials section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.

B. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC, and General Purpose Cabling:
   1. Cable shall consist of copper conductors not less than #18 AWG stranded.
   2. Cable shall be two- or three-conductor twisted cable with a drain wire.
   3. Cable shall have a 100 percent overall shield.
   4. Cable shall be plenum rated.
   5. Cable shall meet or exceed NEC voltage rating of 300 volts.
   6. Cable shall be NEC type CMP.
   7. Cable shall meet or exceed UL temperature rating of +60 deg C.

C. Primary and Secondary Communications Network Cabling:
   1. Cable shall be of type recommended by the DDC system manufacturer.
   2. Cable shall be shielded.
   3. Cable shall be plenum rated.
   4. Cable shall meet or exceed NEC voltage rating of 150 volts.
   5. Cable shall meet or exceed UL temperature rating of +60 deg C.

PART 3 - EXECUTION

3.1 GENERAL

A. Fabrication, erection, and installation of the complete mechanical system shall be done by qualified personnel experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the project.

B. The Contractor shall check all areas and surfaces where mechanical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.

C. Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the mechanical work.

D. Equipment and systems shall be installed in accordance with manufacturer's instructions, requirements, or recommendations.

3.2 DELIVERY AND STORAGE OF MATERIALS

A. Take provisions for the delivery and safe storage of materials and shall make the required arrangements with other Contractors for the introduction into the building of equipment too large to pass through finished openings.

B. Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.

C. Contractor shall be responsible for adequately protecting all supplies and equipment during cold weather.

D. All items subject to cold weather damage shall be protected by covering, insulating, or storing in a heated space.

3.3 COOPERATION WITH OTHER CONTRACTORS

A. Perform the work in conformance with the construction called for by other trades and afford other Contractors reasonable opportunity for the execution of their work.

B. Properly connect and coordinate the mechanical work with the work of other Contractors at such time and in such a manner as not to delay or interfere with their work.

C. Examine the contract documents for the General, Mechanical, and Electrical work and the work of other trades. Coordinate work accordingly.

D. Promptly report to the Engineer any delay or difficulties encountered in the installation of the mechanical work which might prevent prompt and proper installation of work required from other trades.

E. Systems Test and Balance Contractors or personnel shall coordinate their work with the contractors who installed the systems being tested or balanced.

F. The Temperature Control Contractor or personnel shall be present during systems test and balance.

3.4 COORDINATION OF WORK

A. The list below is the precedence of assigned work items for space priority in descending order. Items not listed shall have the same precedence as similar items.
   1. Reflected ceiling with all light fixtures, access above light fixtures required for maintenance, sprinkler head locations, and all ceiling fixtures and devices.
   2. Space designed for future utility placement.
   3. Gravity flow plumbing waste, roof drainage, and other systems that rely upon gravity for flow.
   4. Ductwork and appurtenances, except that external bracing shall be relocated to accommodate local interference.
   5. Fire sprinkler piping.
   6. Cable tray with access identification 8 inches horizontal to 6 inches above tray.
   7. Electrical conduit over 2 inches in diameter.
   8. HVAC piping except for pressurized domestic water piping.
   9. Plumbing vents.
   10. Electrical conduit under 2 inches in diameter.

B. Plan all work so it proceeds with a minimum of interference with other trades.

C. It shall also be the responsibility of the Mechanical Contractor to inform the Contractor of all openings required in the building construction for the installation of the mechanical work.

D. The Contractor shall cooperate with all other contractors in furnishing material and information, in proper sequence, for the correct location of all sleeves, inserts, foundations, wiring, etc.

E. Provisions shall be made for all special frames, openings, and sleeves as required.

F. The Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.5 ELECTRICAL WIRING

A. Install wiring in accordance with National Electric Code, ANSI/NFPA 70.

B. All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable. All wiring running exposed in air plenums shall be plenum cable.

C. Install wiring (low and line voltage) in metal raceways or conduit unless inside control cabinet or unit enclosures.
   1. For concealed and accessible areas, plenum-rated wiring and cabling may be used.

D. Low voltage wiring not installed in conduit shall be supported every five feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.

E. Low voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.

F. Fastening shall be secured to walls or ceilings by means of appropriate screws, expansion screws anchors, toggle bolts, hollow wall screw anchors, nylon expansion anchors, or expansion shields. All-purpose plastic anchors are not acceptable.

G. Locate circuits, relays, transformers, or other equipment that contains or must be connected to voltages exceeding 130 volts, in separate cabinets, which may be adjacent to control panels; permanently label "DANGER 277 VOLTS" or appropriate volts.

H. All wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size shall be 3/4 inch.

3.6 CONTROL WIRING AND POWER CONNECTIONS

A. Provide all incidental control power and wiring required to make the equipment or systems fully operational. Coordinate with equipment manufacture incidental wiring requirements.

B. Unless indicted elsewhere, provide line voltage, 120VAC, 20 amp dedicated control power circuits and LAN outlet to each of the following and as indicated:
   1. BMCS Control panel, 1 circuit.
   2. Coordinate required 120V power circuits and LAN outlets with Electrical Contractor.

C. Incidental control wiring includes but not limited to:
   1. HVAC Controls (Including but not limited to):
      a. Manufacturer's Packaged Control Systems
      b. Transmitters
   2. Packaged Split System Air Handling Units

3.7 LAYING OUT WORK

A. Carefully lay out all work in advance of installation using data and measurements from the site, the appropriate architectural and structural drawings, and shop drawings.

B. Equipment layout and all system layouts shall confirm adequate clearances for installation, operation, maintenance, and code-required clearances from the structure or other equipment and systems.

C. Provide offsets and elevation changes in conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.

D. The layout shall not cause problems of operation, maintenance, or clearance for items installed by other Contractors.

E. Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.

F. If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Engineer prior to installation and shall request clarification.

G. Failure to properly coordinate and lay out the work will require correction by the Contractors at their own expense.

3.8 DATA AND MEASUREMENTS

A. Mechanical and electrical drawings are diagrammatic or schematic. Do not scale drawings.

B. The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.

C. Obtain exact locations, measurements, levels, etc., at the site and shall adapt their work to actual conditions.

D. Examine the general construction, mechanical, electrical, and other applicable drawings and the Specifications.

E. Layout and coordinate all work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.

3.9 POSITION OF DEVICES

A. Locate devices mounted on finished surfaces with regard to paneling, furring, trim, etc. Where several devices occur in a room, they shall be symmetrically arranged as reviewed by the Engineer.

B. Devices improperly located or installed shall be repaired, replaced or relocated at the Contractor's expense.

C. Devices shall be set plumb or horizontal and shall extend to the finished surface of the wall, ceiling, or floor without projecting beyond the surface.

D. Devices shown on wood trim, cases, or other fixtures shall be installed symmetrically and, where necessary, shall be set with the long dimension of the plate horizontal.

E. Coordinate their respective devices so as not to destroy the aesthetic effect of the surface in which the devices are mounted.

F. Coordinate the locations of all mechanical items with work furnished by other trades to avoid interference.

G. If the required coordination is not done, the outlets or devices shall be removed and relocated if so directed by the Engineer and the damaged surfaces repaired at the Contractor's expense.

H. Devices shall be installed at the height shown below unless otherwise noted. All heights of devices are measured from finished floor to centerline of device.

I. Heights may be adjusted to correspond to nearest masonry course or as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.
   1. Temperature control panels: 60 inches
   2. Thermostats: 48 inches
   3. Carbon dioxide (CO2) sensors: 48 inches

3.10 PROTECTION OF APPARATUS

A. Take such precautions as necessary to properly protect all apparatus, fixtures, appliances, material, equipment, and installations from damage of any kind.

B. Failure to provide such protection to the satisfaction of the Engineer shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.11 ACCESS TO EQUIPMENT

A. All motors, terminal boxes, valves, control devices, specialties, etc., shall be located to provide for easy access for operation, repair and maintenance; if concealed, access doors shall be provided.

B. Access doors required for access to equipment requiring inspection or service shall be provided.

C. Provide all access doors not already furnished by other Contractors but which are required for access to mechanical equipment.

D. Doors shall be 12 inches by 12 inches unless shown otherwise.

E. Person access doors shall be 18 inches by 18 inches minimum.

3.12 ROADWAYS, CURBS, AND WALKS

A. Use every possible precaution to prevent injuries to roadways, curbs, and walks on or adjacent to the site of the work.

B. Any damage shall be repaired at the Contractor's own expense. This shall also include damage necessary for installation of the mechanical work.

3.13 WORK IN EXISTING BUILDINGS

A. General: All work in the existing building, indicated on the drawings or specified herein, shall be executed with a minimum amount of interference with the normal activities of the occupants of the building.

B. All work shall be scheduled in advance with the Owner and shall not proceed without the Owner's written approval.

C. Utilities: Utilities shall not be interrupted without the Owner's prior written approval regarding the time and duration of such interruptions.
1. Utilities to existing facilities shall not be disconnected until new or temporary facilities are installed except for short periods of interruption which are necessary for the performance of the new work and which are approved by the Owner.

D. Storm water may be temporarily diverted to surface drainage provided such drainage is arranged to prevent flooding of structures, basements, and excavations for construction.

E. Fire Alarm System: The existing fire alarm system shall remain functional throughout construction.
1. As a minimum, the existing degree of protection shall be maintained for all areas.
2. All required outages shall be coordinated with the Owner and the Fire Marshal.

F. Welding: The Owner shall be notified before starting welding or cutting.
1. Fire extinguishers shall be immediately accessible when welding or cutting with an open flame or arc.
2. Welding or cutting with an open flame or arc shall be stopped not less than one hour before leaving the premises.

G. Noisy Operations: Noisy operations such as those involving use of air hammers, etc., in demolition, or cutting of openings shall be scheduled with the Owner.

H. Occupancy:
1. The Owner will continue to occupy the building and carry on normal activity. Each Contractor shall protect the occupied areas from dust, smoke, etc., by a method reviewed by the Engineer.

I. Owner's Right to Direct Work: The Owner shall have the right to direct the places of beginning work, its prosecution, and the manner in which all work under this contract is to be conducted, insofar as may be necessary to secure the safe and proper progress and quality of the work.

J. Coordinate locations of new fire suppression, plumbing and HVAC penetrations through existing structure and construction. Utilize all existing documentation of conditions for coordination. Verify penetrations utilizing GPR (Ground Penetrating Radar) as necessary to confirm penetration locations.

K. Cutting and Patching:
1. Each Contractor shall be responsible for all cutting and patching required for the work.
2. Patching shall be done by persons skilled in the trade involved and shall be prepared to receive paint.
3. Openings through floors may be drilled up to 1 inch but shall be core drilled over 1 inch.
4. Whenever the building surfaces (walls, floors, etc.) and openings are modified, removed and/or replaced to accommodate the new work or to introduce into or remove items from the building, such surfaces or openings shall be carefully reinstalled in conformance with the applicable code to protect the integrity of the building.

L. Existing Piping, Ductwork, or Mechanical Equipment:
1. If any existing piping, ductwork or mechanical equipment is encountered which would interfere with the proper installation of new work, it shall be removed or relocated as required or as directed by the Engineer.
2. Where existing work is to be modified, it shall be done in conformance with these specifications.
3. Materials used shall be the same as for new work unless otherwise specified.

3.14 DEMOLITION

A. Information pertaining to the existing building has been obtained through the buildings original drawings where available. Report discrepancies to the architect/engineer prior to any demolition. Contractor shall field verify all existing conditions prior to commencing work.

B. The Owner shall have the first right of salvage for all items being removed or demolished. If owner declines, the contractor shall remove from the premises and dispose of properly. Verify owner's intent prior to removal or demolition.

C. Coordinate shut down of all utilities for demolition work with the owner.

D. Coordinate demolition with the work of other trades. Provide temporary utilities as required to allow the work of other trades to proceed.

E. Remove all items and systems as indicated.

F. Disconnect, demolish, and remove systems, equipment, and components indicated to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

G. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.15 FINISHED SURFACES PENETRATIONS

A. All piping and ductwork penetrations of finished surfaces shall have escutcheons and/or closure plates.

B. Openings shall be cut only as large as required for the installation, sleeves, and/or frames installed flush with finished surfaces and grouted in place.

C. Surfaces around openings shall be left smooth and finished to match surrounding surface.

D. Duct frames and pipe sleeves through floors in concealed locations and in unfinished spaces such as mechanical rooms, etc., shall extend 2 inches above finished floor level and shall be caulked watertight.

E. All other sleeves shall extend approximately 1/4 inch above finished floor but shall allow placement of escutcheons.

3.16 FIRESTOPPING PENETRATIONS IN FIRE-RATED WALL/FLOOR ASSEMBLIES

A. Subject to compliance with the requirements of Division 07.

B. Provide proper sizing when providing sleeves or core-drilled holes to accommodate their work through penetrating items.

C. All voids between sleeve or core-drilled hole and pipe passing through shall be firestopped to meet the requirements of ASTM E814.

D. Install all materials complete, attached securely and permanently in place in accordance with manufacturers' printed directions.

E. Install materials in manner described in fire test report and in accordance with manufacturer's instructions, completely closing openings.

F. Do not cover installed firestopping until inspected by authority having jurisdiction.

G. Install labeling required by code.

3.17 PIPING AND/OR DUCTWORK SYSTEMS - COMMON REQUIREMENTS

A. General: Install as described below, unless individual Sections specify otherwise. Individual Sections specify unique installation requirements.

B. General Locations and Arrangements:

1. Drawing plans, schematics, and diagrams indicate general, diagrammatic location and arrangement of systems.
2. Indicated locations and arrangements were used to sizeductwork and calculate friction loss and fan sizing, and other design considerations.
3. Install systems as indicated, unless deviations to layout are approved on Coordination Drawings.
4. Provide offsets and elevation changes in ductwork, piping and conduit as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
5. Do not run ductwork and piping above electrical panels or in code required clearance spaces.
6. Do not run ductwork, piping, and plumbing above or through information technology and data closets, IDF, and MDF rooms. Coordinate all routing with other trades.
7. Coordinate location of ductwork with electrical cable tray. Provide a minimum of 6" of clear access above cable tray for installation of cables.
8. Install exposed interior and exterior piping and ductwork at right angles or parallel to building walls.
    a. Diagonal runs are prohibited, unless otherwise indicated.
9. Conceal ductwork in walls, pipe chases, utility chases, above ceilings, below grade or floors, unless otherwise noted, except in mechanical rooms or service areas.
10. Install ductwork to allow application of insulation plus 1-inch clearance around insulation.
11. Provide components with pressure rating equal to or greater than system operating pressure.
12. Install fittings for changes in direction and branch connections.
13. Install piping free of sags or bends with ample space between piping to permit proper insulation applications.
14. Install ductwork and piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building unless otherwise indicated.
    a. Allow sufficient space above ceiling panels to allow for ceiling panel removal.
15. Install ductwork and piping to allow for expansion and contraction without stressing pipe, adjacent building structure or connecting equipment.
    a. Provide expansion loops or compensators where indicated.
16. Do not use ceiling support system to bear weight of devices or systems unless ceiling support system is certified as suitable to do so.
17. During construction, avoid any undue loads, forces or strains on valves, equipment, pumps flanges, or building elements with piping connections or piping systems.

18. Keep all duct and equipment openings closed during construction except when actual work is being performed on that item or system.
19. Roof mounted piping, conduit and ductwork:
    a. Coordinate all roof mounted support locations and loads with roofing contractor.
    b. Space supports per all applicable codes and as indicated.
    c. Provide 18" minimum under pipe, duct and conduit, to allow for roof repair.

C. Contractor is responsible for any cutting and patching needed for mechanical installation. Patching must match existing.

D. Verify final equipment locations for roughing-in of all systems.

3.18 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to manufacturer's requirements and submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Engineer.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components.

E. Connect equipment for ease of disconnecting, with minimum interference to other installations.

3.19 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS D1.1, "Structural Welding Code--Steel."

3.20 INCIDENTAL WORK

A. The following incidental work shall be furnished by the designated contractor under the supervision of the Temperature Control Contractor:
    1. The Air Distribution Contractor shall install all automatic dampers furnished by the Temperature Control Contractor.
    2. The Air Distribution Contractor shall provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
    3. The Air Distribution Contractor shall provide access doors or other approved means of access through ducts for service to control equipment.

3.21 LUBRICATION, TESTING AND TEST REPORTS

A. Upon completion of the work, the entire system shall be tested and proven for capacity of equipment, balance of system, proper operation of controls, and comfort of conditioned spaces.
   1. Prior to beginning systems testing, adjusting and balancing, replace all filter media with new media.
   2. Test and balance procedures and documentation shall be in accordance with AABC, NEBB, or SMACNA unless indicated otherwise.
   3. Take air readings and submit copy of same to demonstrate proper flow according to the performances shown on the plans and noted in the specifications.
   4. Lubricate moving parts and clean or replace filters.
      a. Run in all bearings and, after they are run in, drain and flush bearings and refill with a new oil charge.
      b. Equipment shall be so arranged that tools (screwdrivers, wrenches, etc.) will not be required to make lubrication points accessible.
      c. Extensions on grease or oil fittings shall be provided where required for access to lubricate.
   5. Test ductwork systems per SMACNA and applicable codes and standards.
   6. Submit all test reports to the Engineer for review prior to date of substantial completion.
   7. Equipment and systems discrepancies shall be corrected prior to final acceptance.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Stencils.

D. Pipe markers.

E. ASME A13.1 - Scheme for the Identification of Piping Systems.

F. ASTM D709 - Standard Specification for Laminated Thermosetting Materials.

1.2 SUBMITTALS

A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

C. Product Data: Provide manufacturers catalog literature for each product required.

D. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Split System Air Handlers, Concealed: Stencilled painting or nameplastes.

B. Control Panels: Nameplates.

C. Piping: Pipe markers.

D. Relays: Tags.

E. Thermostats and space sensors: Nameplates.

2.2 NAMEPLATES

A. Manufacturers:
   1. Advanced Graphic Engraving, LLC: www.advancedgraphicengraving.com.
   2. Brimar Industries, Inc.: www.pipemarker.com.
   3. Craftmark Pipe Markers: www.craftmarkid.com/#sle.

4. Kolbi Pipe Marker Co.: www.kolbipipemarkers.com.
5. Seton Identification Products, a Tricor Direct Company: www.seton.com.

B. Description: Laminated three-layer plastic with engraved letters.
1. Letter Color: White.
2. Letter Height: 1/2 inch.
3. Background Color: Black.
4. Plastic: Comply with ASTM D709.

2.3 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch octagonal.

B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch octagonal with smooth edges.

C. Valve Tag Schedule: In Valve and Equipment Binder.

2.4 STENCILS

A. Stencils: With clean cut symbols and letters of following size:
1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
4. Ductwork and Equipment: 2-1/2 inch high letters.

B. Stencil Paint: Semi-gloss enamel, colors complying with ASME A13.1.

2.5 PIPE MARKERS

A. Color: Comply with ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.

D. Color code as follows:
1. Heating, Cooling, and Boiler Feedwater: Green with white letters.
2. Toxic and Corrosive Fluids: Orange with black letters.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 TAGS

A. Install tags with corrosion-resistant chain.

B. Identify valves in main and branch piping with tags.

C. Identify air terminal units coil valves with numbered tags.

D. Tag automatic controls, instruments, and relays. Keep to control schematic.

E. Identify small devices such as in-line pumps with tags.

F. Identify pipe 1 inch and smaller with tags.

3.3 PIPE MARKERS

A. Install plastic pipe markers in accordance with manufacturer's instructions.

B. Install plastic tape pipe markers complete/around pipe in accordance with manufacturer's instructions.

C. Identify piping, concealed or exposed, with plastic pipe markers. Identify service, flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure and at each obstruction.

D. All underground piping systems shall have a non-metallic warning tape, with appropriate warning, buried 24 inches above top of pipe.

3.4 NAME PLATES

A. Install plastic name plates with the manufacturer's recommended adhesive.

B. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates.

C. Identify control panels and major control components outside panels with plastic nameplates.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems and components.

B. Measurement of final operating condition of HVAC systems.

1.2 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 indicated 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. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

J. 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.

K. TAB: Testing, adjusting, and balancing.

L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

M. Test: A procedure to determine quantitative performance of systems or equipment.

N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 REFERENCE STANDARDS

A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition.

B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.

C. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems.

D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing.

E. TABB - Testing, Adjusting, and Balancing Bureau.

1.4 SUBMITTALS

A. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to Engineer.
   2. Submit six weeks prior to starting the testing, adjusting, and balancing work.
   3. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified below and in Part 3.
   4. Include certification that the plan developer has reviewed Contract Documents, the equipment and systems, and the control system with the Engineer and other installers to sufficiently understand the design intent for each system.
   5. Include at least the following in the plan:
      a. Preface: An explanation of the intended use of the control system.
      b. List of all air flow, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      d. Identification and types of measurement instruments to be used and their most recent calibration date.
      e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      f. Final test report forms to be used.
      g. Detailed step-by-step procedures for TAB work for each system and issue, including:
         1) Terminal flow calibration (for each terminal type).
         2) Diffuser proportioning.
         3) Branch/submain proportioning.
         4) Total flow calculations.
         5) Rechecking.

6) Diversity issues.

h. Expected problems and solutions, etc.

i. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.

j. Details of how TOTAL flow will be determined; for example:

1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.

k. Specific procedures that will ensure that both air side systems are operating at the lowest possible pressures and methods to verify this.

l. Confirmation of understanding of the outside air ventilation criteria under all conditions.

m. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).

n. Method of checking building static and exhaust fan and/or relief damper capacity.

o. Proposed selection points for sound measurements and sound measurement methods.

p. Methods for making coil or other system plant capacity measurements, if specified.

q. Time schedule for TAB work to be done in phases (by floor, etc.).

r. Description of TAB work for areas to be built out later, if any.

s. Time schedule for deferred or seasonal TAB work, if specified.

t. False loading of systems to complete TAB work, if specified.

u. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.

v. Interstitial cavity differential pressure measurements and calculations, if specified.

w. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

x. Procedures for formal progress reports, including scope and frequency.

y. Procedures for formal deficiency reports, including scope, frequency and distribution.

B. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

1. Revise TAB plan to reflect actual procedures and submit as part of final report.

2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.

3. Provide reports in electronic, word searchable, .pdf format binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.

5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.

6. Units of Measure: Report data in I-P (inch-pound) units only.
7. Include the following on the title page of each report:
    a. Name of Testing, Adjusting, and Balancing Agency.
    b. Address of Testing, Adjusting, and Balancing Agency.
    c. Telephone number of Testing, Adjusting, and Balancing Agency.
    d. Project name.
    e. Project location.
    f. Project Engineer.
    g. Project Engineer.
    h. Project Contractor.
    i. Project altitude.
    j. Report date.
    k. Certification sheet signed and sealed by the certified testing and balancing engineer.

C. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

D. Project Record Documents: Record actual locations of flow measuring stations, balancing dampers, and balancing dampers.

E. As-Balanced Record Fan Curves: Record actual balanced points on the manufacture's submitted fan curves.
1. Record system curves and actual RPM data for all fans.
2. Record system curves, actual RPM and final impeller diameter for all pumps.

F. Final Report Contents: In addition to certified field report data, include the following:
1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

1.5 PROJECT CONDITIONS

A. The entire TAB process shall be completed prior to Owner Occupancy.

1.6 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. 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.

1.7 WARRANTY

A. National Project Performance Guarantee: 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:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS

2.1 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
   1. AABC (NSTSB), AABC National Standards for Total System Balance.
   2. SMACNA (TAB).
   3. Maintain at least one copy of the standard to be used at project site at all times.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

D. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
   2. Having minimum of three years documented experience.
   3. Certified by one of the following:
      a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
      b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
      c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Fans are rotating correctly.
   7. Fire and volume dampers are in place and open.
   8. Air coil fins are cleaned and combed.
   9. Access doors are closed and duct end caps are in place.
   10. Air outlets are installed and connected.
   11. Duct system leakage is minimized.
   12. Balancing dampers and devices are installed.

B. Examine equipment performance data including fan curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory.

C. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

D. Examine system and equipment test reports.

E. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

F. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

G. 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.

H. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

I. Examine equipment for installation and for properly operating safety interlocks and controls.

J. Examine automatic temperature control and building automation system components to verify the following:
   1. Check the sequence of operation of control devices are according to the Contract Documents..
   2. Dampers and other controlled devices are operated by the intended controller.
   3. Dampers are in the position indicated by the controller.
   4. Integrity of ampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in variable-air-volume terminals.
   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. Controller set points are set at indicated values. Controllers are calibrated and commissioned. Record controller settings and note variances between set points and actual measurements.
   8. Changeover from heating to cooling mode occurs according to indicated values.
   9. Transmitter and controller locations and note conditions that would adversely affect control functions.
   10. Operation of limiting controllers (i.e., high- and low-temperature controllers).
   11. Free travel and proper operation of control devices such as damper and valve operators.
   12. Interaction of electrically operated switch transducers.
   13. Interaction of interlock and lockout systems.
   14. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
   15. Note operation of electric actuators using spring return for proper fail-safe operations.

K. 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.

L. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing.

3.4 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.5 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", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems-Testing, Adjusting, and Balancing", and this Section.

B. Cut insulation, ducts and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.6 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
1. Running log of events and issues.
2. Discrepancies, deficient or uncompleted work by others.
3. Contract interpretation requests.
4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings dampers and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.7 AIR SYSTEM PROCEDURE

A. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

B. Check dampers for proper position to achieve desired airflow path.

C. Check for airflow blockages.

D. Check condensate drains for proper connections and functioning.

E. Check for proper sealing of air-handling unit components.

F. Check for proper sealing of air duct system.

G. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

H. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

I. Measure air quantities at air inlets and outlets.

J. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

K. Adjusting:
1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, as directed and as required to prevent drafts before starting air balancing.
2. Adjust air patterns per manufactures recommendations based on installed conditions.

L. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

M. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

N. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

O. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

P. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

Q. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

R. Where modulating AHU fans are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

S. On electric heating coils, adjust system to provide required minimum airflow or downstream pressure differential to activate controls.

3.8 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.9 SCOPE

A. Test, adjust, and balance the following:
1. Packaged Split Syst Heating/Cooling Units.
2. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

A. Packaged Split System Heating/Cooling Units:
1. Unit identification.
2. Location.
3. Make and type.
4. Model number and unit size.
5. Manufacturer's serial number.
6. Unit arrangement and class.
7. Discharge arrangement.
8. Motor Data:
a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
g. Variable frequency controller position.
9. Total airflow rate in cfm.
10. Return air flow, specified and actual
11. Outside air flow, specified and actual, if applicable
12. Total system static pressure in inches wg.
13. Fan rpm.
14. Discharge static pressure in inches wg.
15. Filter static-pressure differential in inches wg.
16. Outside-air damper position.
17. Return-air damper position.

B. Supply Fans:
   1. Unit identification.
   2. Location.
   3. Manufacturer.
   4. Model number.
   5. Serial number.
   6. Arrangement/Class/Discharge.
   7. Air flow, specified and actual.
   8. Total static pressure (total external), specified and actual.
   9. Inlet pressure.
   10. Discharge pressure.
   11. Fan RPM.

C. Return Air/Outside Air:
   1. Identification/location.
   2. Design air flow.
   3. Actual air flow.
   4. Design return air flow.
   5. Actual return air flow.
   6. Design outside air flow.
   7. Actual outside air flow.
   8. Return air temperature.
   9. Outside air temperature.
   10. Required mixed air temperature.
   11. Actual mixed air temperature.
   12. Design outside/return air ratio.
   13. Actual outside/return air ratio.

D. Duct Traverses:
   1. System zone/branch.
   2. Duct size.
   3. Area.
   4. Design velocity.
   5. Design air flow.
   6. Test velocity.
   7. Test air flow.
   8. Duct static pressure.
   9. Air temperature.
   10. Air correction factor.

E. Air Distribution Tests:
   1. Air terminal number.
   2. Room number/location.
   3. Terminal type.
   4. Terminal size.
   5. Area factor.
   6. Design velocity.
   7. Design air flow.
   8. Test (final) velocity.

9. Test (final) air flow.
10. Percent of design air flow.

F. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

END OF SECTION

SECTION 23 07 13

DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Duct insulation.

B. Duct liner.

C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.

F. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.

G. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

I. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

J. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

K. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

L. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.2 SUBMITTALS

A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations. Show details for application of field-applied jackets.

B. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of experience and approved by manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density, thickness, and appropriate ASTM standard designation.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.5 FIELD CONDITIONS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723.

B. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Insulation products shall not contain asbestos, lead, mercury, mercury compounds, or formaldehyde.

E. Products shall be certified by UL GREENGUARD GOLD or Indoor Advantage Gold.

F. Products shall certified to meet or exceed UL Standard 2818 -2013 Gold Standard for Chemical Emissions for Building Materials, Finishes and Furnishings

G. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

H. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

2.2 GLASS FIBER, FLEXIBLE

A. Manufacturer:
1. CertainTeed Corporation: www.certainteed.com.
2. Johns Manville Corporation; : www.jm.com.
3. JP Lamborn Co: www.jpflex.com.
4. Knauf Insulation: www.knaufinsulation.com.
5. Manson Insulation, Inc.: www.mansoninsulation.com
6. Owens Corning Corp; : www.owenscorning.com.

B. Vapor Barrier Jacket:
1. FSK: Kraft paper with glass fiber scrim yard and bonded to aluminized film; 0.0032 inch vinyl.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.

C. Vapor Barrier Tape:
1. Aluminized foil film, with pressure sensitive acrylic based adhesive, 3 inches wide, 6.5 mils thick, 58-ounce force/inch adhesion, 23 lbf/inch tensile strength. Service temperature -40 - 250 degree F.

2.3 GLASS FIBER, RIGID

A. Manufacturer:
1. CertainTeed Corporation: www.certainteed.com.
2. Johns Manville Corporation; : www.jm.com.
3. Knauf Insulation: www.knaufinsulation.com.
4. Manson Insulation, Inc.: www.mansoninsulation.com
5. Owens Corning Corporation: www.ocbuildingspec.com.

B. Insulation: ASTM C 612; rigid, noncombustible board.
1. K Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
2. Maximum Service Temperature: 450 degrees F.
3. Maximum Water Vapor Absorption: 5.0 percent.
4. Maximum Density: 8.0 pcf.

C. Vapor Barrier Jacket:
1. FSK: Kraft paper with glass fiber scrim yard and bonded to aluminized film; 0.0032 inch vinyl.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.

D. Vapor Barrier Tape:
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive, 3 inches wide, 6.5 mils thick, 90-ounce force/inch adhesion, 40 lbf/inch tensile strength.

E. Indoor Vapor Barrier Finish:
1. Manufacturers:
a. Fosters Model Vapor Out 30-33.
b. Childers Model Chil Out, CP-33.
2. Cloth: Untreated; 9 oz/sq yd min. weight, glass fabric.
3. Vinyl emulsion type acrylic, compatible with insulation, white color.
4. Characteristics: 0.07 perm water-vapor permeance per ASTM E96, Procedure B at 45 mil dry film thickness; -20 degrees F to +180 degrees F temperature range; solid content, 55 percent by volume and 68 percent by weight per ASTM D 1644; white color.

2.4 DUCT LINER

A. Manufacturers:
1. Aeroflex USA, Inc: www.aeroflexusa.com.
2. Armacell LLC: www.armacell.us.
3. CertainTeed Corporation: www.certainteed.com.
4. Ductmate Industries, Inc, a DMI Company: www.ductmate.com.
5. Johns Manville: www.jm.com.
6. Owens Corning Corporation: www.ocbuildingspec.com.
7. RBX Corporation.

B. Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
1. Minimum Service Temperature: Minus 40 degrees F.
2. Maximum Service Temperature: 180 degrees F.
3. Fungal Resistance: No growth when tested according to ASTM G21.
4. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
5. Minimum Noise Reduction Coefficients:
a. 1/2 inch Thickness: 0.30.
b. 1 inch Thickness: 0.40.
c. 1-1/2 inches Thickness: 0.50.
d. 2 inch Thickness: 0.60.
6. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm when tested in accordance with ASTM C1071.
7. Connection: Waterproof vapor barrier adhesive.
8. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Insulated Ducts Conveying Air Below Ambient Temperature:
1. Provide insulation with vapor barrier jackets, with minimum installed R-value of 6.0.
2. Finish with tape and vapor barrier jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

D. Insulated Ducts Conveying Air Above Ambient Temperature:
1. Provide with or without standard vapor barrier jacket, with minimum installed R-value of 6.0.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

E. External Duct Insulation Application:
1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
2. Secure insulation without vapor barrier with staples, tape, or wires.
3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
6. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
    a. Apply adhesives according to manufacturer’s recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
    b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
    c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
        1) On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
        2) On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
        3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
        4) Do not overcompress insulation during installation.
        5) Impale insulation over pins and attach speed washers.

6) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor barrier mastic, and sealant at joints, seams, and protrusions.
   1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor barrier seal.
   2) Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness but not less than 3 inches.

e. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

f. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface.

g. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

7. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transition.
   c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
      1) On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      2) On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      4) Do not overcompress insulation during installation.

5) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor barrier mastic, and sealant at joints, seams, and protrusions.

1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor barrier seals.

2) Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness but not less than 3 inches.

e. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows.

f. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Duct Liner Application:

1. Adhere insulation with adhesive for 100 percent coverage.
2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.
6. Lined ducts shall be fabricated to provide the net inside dimensions shown.
7. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
8. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
9. Butt transverse joints without gaps and coat joint with adhesive.
10. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
11. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
12. Apply adhesive coating on all longitudinal seams.

13. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
14. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

3.3 DUCT INSULATION

A. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

B. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

C. Items Not Insulated:
1. Existing supply air and outside air ductwork that has existing duct wrap insulation or liner.
    a. Note: All new supply air and outside air ductwork shall be insulated. Uninsulated existing ductwork connecting to the new ductwork shall be insulated.
2. Existing ductwork concealed in chases.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Factory-insulated rooftop unit curbs.
6. Flexible connectors.
7. Vibration-control devices.
8. Factory-insulated access panels and doors.

3.4 INSULATION AND JACKET SCHEDULE

A. Duct Liner
1. Duct liner shall not be used on the following locations:
    a. Ahead of any coil on all air distribution systems.
2. Horizontal Split System Air Handling Units (AH-1):
    a. Supply Air: 1-inch liner in all new ductwork downstream of unit. Existing ductwork connected to the new ductwork shall not be lined.
    b. Return Air: 1-inch liner in all new ductwork upstream of unit. Existing ductwork connected to the new ductwork shall not be lined.

B. Indoor Duct and Plenum
1. Supply Air:
    a. Concealed, supply-air duct insulation shall be any of the following:

1) Glass-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
2) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

b. Exposed on mechanical mezzanine, rectangular, supply-air duct insulation shall be any of the following:
1) Glass-Fiber Blanket: 2 inchesthick and 1.5-lb/cu. ft.nominal density.
2) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.
3) Glass-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
4) Note: New ductwork shall be insulated. Existing ductwork does not need to be reinsulated except where damaged during new construction.

c. Exposed on mechanical mezzanine, round or flat oval, supply-air duct insulation shall be any of the following:
1) Glass-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
2) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

2. Return Air:
a. Concealed, rectangular, return-air insulation shall be any of the following:
1) None.

b. Exposed on mechanical mezzanine, rectangular, return-air duct insulation shall be any of the following:
1) Glass-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
2) Glass-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

3. Outdoor Air:
a. Exposed on mechanical mezzanine, rectangular, outdoor-air duct insulation shall be any of the following:
1) Glass-Fiber Blanket: 3 inchesthick and 1.5-lb/cu. ft.nominal density.
2) Glass-Fiber Board: 3 inches thick and 3-lb/cu. ft. nominal density.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Jacketing and accessories.

C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

D. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.

F. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

G. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.

H. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.

I. ASTM C585 - Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.

J. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.

K. ASTM C610 - Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation.

L. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.

M. ASTM D1056 - Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.

N. ASTM D2842 - Standard Test Method for Water Absorption of Rigid Cellular Plastics.

O. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

P. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

Q. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.2 SUBMITTALS

A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

B. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section and approved by manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.5 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Products shall be certified by UL GREENGUARD GOLD or Indoor Advantage Gold.

F. Products shall certified to meet or exceed UL Standard 2818 -2013 Gold Standard for Chemical Emissions for Building Materials, Finishes and Furnishings

G. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

H. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

2.2 GLASS FIBER, RIGID

A. Manufacturers:
1. CertainTeed Corporation: www.certainteed.com/#sle.
2. Johns Manville Corporation: www.jm.com/#sle.
3. Knauf Insulation: www.knaufinsulation.com/#sle.
4. Owens Corning Corporation: www.ocbuildingspec.com/sle.
5. Manson Insulation.

B. Insulation: ASTM C547and ASTM C795; rigid molded, noncombustible.
1. K Value: ASTM C177, 0.24 at 75 degrees F.
2. Maximum Service Temperature: 850 degrees F.
3. Maximum Moisture Absorption: 0.2 percent by volume.

C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

2.3 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

A. Manufacturers:
1. Aeroflex USA, Inc: www.aeroflexusa.com/#sle.
2. Armacell International; Armaflex: www.armacell.com.
3. K-Flex USA LLC: www.kflexusa.com/#sle.
4. RBX Corp.

B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
1. K Value: {rs#1}; 0.25 at 75 degrees F.
2. Minimum Service Temperature: Minus 40 degrees F.
3. Maximum Service Temperature: 220 degrees F.
4. Moisture Vapor Permeability: .03 perm inch, when tested in accordance with {rs#1}.
5. Connection: Waterproof vapor barrier adhesive.

C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.4 JACKETS AND COVERS

A. PVC Plastic:
1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
a. Minimum Service Temperature: 0 degrees F.
b. Maximum Service Temperature: 150 degrees F.

c. Moisture Vapor Permeability: .02 perm inch, maximum, when tested in accordance with {rs#1}.
d. Thickness: 10 mil, 0.010 inch.
e. Connections: Brush on welding adhesive.

2. Covering Adhesive Mastic: Compatible with insulation.
a. Manufacturers:
1) Childers Products Vi Cryl CP-10/11.
2) Foster Products Weatherite 46-50.
3) Eagle Bridges - Marathon Industries, Inc.

B. Self-Adhering Jacketing:
1. Manufacturers:
a. Venture Tape
b. Fosters
c. Polyguard
2. Jacket: Multi-ply, laminated, flexible, self-adhering, protective jacketing, vapor barrier, and weatherproofing membrane.
a. Maximum Service Temperature: 250 degrees F.
b. Minimum Service Temperature: -40 degrees F.
c. Moisture Vapor Permeability: 0000 per inch, when tested in accordance with ASTM E-96.
d. Mold inhibitors incorporated.
e. UV stable.
f. Minimum Thickness: 5.0 mils.

2.5 ACCESSORIES

A. General Requirements:
1. Provide required accessories in accordance with and subject to the recommendations of the insulation manufacturer.
2. Furnish compatible materials which do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state.
3. Comply with ASTM C795 requirements for materials to be used on stainless steel surfaces.
4. Supply materials that are asbestos free.

PART 3 EXECUTION

3.1 EXAMINATION

A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Exposed Piping: Locate insulation and cover seams in least visible locations.

D. Insulated Pipes Conveying Fluids Below Ambient Temperature:
1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

E. Glass Fiber Insulated Pipes Conveying Fluids Below Ambient Temperature:
1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Coat all elbows, fittings, valves and flanges with vapor barrier mastic and reinforcing mesh. Finish with PVC fitting covers.

F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

G. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

H. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:
1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with PVC fitting covers.

I. Inserts and Shields:
1. Application: Insulated piping 3/4 inches diameter or larger.
2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
3. Shield shall span an arc of 180 degrees.
4. Match diameter of shield to OD of insulation.
5. Shield dimensions shall not be less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
6. Insert location: Between support shield and piping and under the finish jacket.
7. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
8. Thermal-Hanger Shield Inserts: Install according to manufacturer’s written instructions.

J. Insulated Piping: Attach hangers and supports to piping as follows:
1. Piping Operating Above Ambient Temperature:
   a. Where piping is not supported on rollers or trapeze, hangers may project through insulation.
   b. For straight runs of piping, at points of support more than 100 feet from elbow or anchor point, use roller type supports.
   c. Where piping is supported on rollers or trapeze, support piping at outside diameter of insulation.

1) NPS Smaller than 2: Provide MSS SP-58, Type 40, protective shield.

2. Piping Operating Below Ambient Temperature: Support piping at outside diameter of insulation. Do not penetrate vapor barrier.
   a. NPS Smaller than 2: Provide MSS SP-58, Type 40, protective shield.

K. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, see Section 07 84 00.

3.3 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this Article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

3.4 INSULATION AND JACKET SCHEDULE

A. Insulation thickness listed below is based on the thermal conductivity performance of the material listed.
   1. Alternative material thickness must be adjusted as required to provide equivalent conductivity performance.
   2. Alternative material subtitution shall be reviewed by the Engineer.

B. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

C. Indoor Piping:
   1. Refrigerant Piping and Tubing:
      a. Low Pressure Suction/Vapor (40-90 degrees F), all pipe sizes:
         1) Flexible Elastomeric: 1 inch thick.
      b. Liquid, all pipe sizes:
         1) Flexible Elastomeric: 1 1/2 inches thick.
   2. Condensate and Equipment Drain Water Below 60 Degrees F:
      a. All Pipe Sizes:
         1) Glass-Fiber, Preformed Pipe, Type I: 1/2 inch thick.

D. Outdoor, Above Ground Piping:
   1. Refrigerant Piping and Tubing:
      a. Low Pressure Suction/Vapor (40-90 degrees F), all pipe sizes:
         1) Flexible Elastomeric: 1 inch thick.
      b. Liquid, all pipe sizes:
         1) Flexible Elastomeric: 1 1/2 inches thick.
      c. Outdoor Jacketing: Self-Adhering or Removable UV and Vapor protection.

E. Outdoor, Field Applied Jacket and Covers:
   1. Install jacket/covers over all insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
   2. Piping, Exposed:
      a. Self-Adhering Jacketing: VentureClad, 1579GCW-WME, embossed white with adhesive and a membrane.
      b. Aluminum Jacket Fitting Covers (For Outdoor Use) :
         1) Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch (0.41 mm) with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
         2) Finish: White, Embossed.
         3) Fittings: 0.016 inch (0.40 mm) thick die-shaped fitting covers with factory-attached protective liner.

4) Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.

B. Sequence of operation for:
   1. Packaged split system air handling unit (variable volume, single zone) - AH-1/ACCU-1.
   2. Duplex packaged split system air handling units (constant volume, single zone) AH-2/ACCU-2 and AH-3/ACCU-3

1.2 SYSTEM DESCRIPTION

A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

1.3 SUBMITTALS

A. Specification Compliance Review.

B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
   1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
   2. Include at least the following sequences:
      a. System off.
      b. Start-up.
      c. Warm-up mode.
      d. Normal operating mode.
      e. Unoccupied mode.
      f. Shutdown.
      g. Capacity control sequences and equipment staging.
      h. Temperature and pressure control, such as setbacks, setups, resets, etc.
      i. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
      j. Effects of power or equipment failure with all standby component functions.
      k. Sequences for all alarms and emergency shut downs.
      l. Seasonal operational differences and recommendations.
   3. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other

control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

4. For packaged controlled equipment, include manufacturer's furnished sequence of operation including the above sequences.
5. Include schedules, if known.

C. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 OPERATING SEQUENCES - GENERAL

A. Sequence of Control indicated illustrates basic control function only. Provide all control devices required for controlling air handling units and all related items. Provide monitoring only devices as indicated.

B. The Control Contractor shall perform the initial input of all required setpoint data in the manufacturer-provided controls of packaged equipment to be used based on information supplied to the Contractor by the Owner. The Contractor shall assist the Owner's staff in developing the schedule and shall demonstrate the operation of the system using the data.

3.2 PACKAGED SPLIT SYSTEM AIR HANDLING UNIT (VARIABLE VOLUME, SINGLE ZONE) - AH-1/ACCU-1

A. NOTE: The sequence of operation below is a generic representation of the proprietary sequence programmed in the manufacturer's onboard controller. It is not intended to override any operations of the the manufacturer's sequence.

B. System Off - When the system is off:
1. The outside air damper shall be closed.
2. The return air damper shall be open.
3. Supply fan shall be off.
4. DX cooling shall be off.
5. Electric heat shall be off.

C. Initiation of System Start-Up - The system shall be started:
1. Manually initiated by operator through the manufacturer's controls.
2. Automatically by the manufacturer's controls according to the occupancy schedule.

D. System Operation - After system start-up has been initiated the following shall occur:
1. The supply fans shall be started at minimum speed. After a time period defined by the manufacturer's controls, the fans shall be enabled for automatic speed control.
2. The supply fan speed shall modulate according to the manufacturer's single zone variable air volume controls to maintain the supply static pressure setpoint.

3. The DX cooling shall modulate according to the manufacturer's controls to maintain the space air temperature set point.
4. The electric heater shall modulate according to the manufacturer's controls to maintain the space air temperature set point.
5. Economizer Control:
   a. The manufacturer's economizer controls shall not be used.
6. CO2-Based Demand Controlled Ventilation: The outside air damper in the remote mixing box shall modulate to the outside air damper opening percentage setpoint according to the manufacturer's controls. The damper position setpoint is calculated according to the manufacturer's controls based on the space CO2 reading, which is measured by the manufacturer provided space CO2 sensor, and the maximum damper opening percentage.

E. Dehumidification Mode:
1. Shall be initiated as follows: Automatically when the relative humidity or dew point in the space rises above the dehumidification set point.
2. The DX cooling and/or fan speed shall modulate according to the manufacturer's controls to maintain the space humidity setpoint.
3. The electric heating coil shall modulate according to the manufacturer's controls to reheat the dehumidified supply air back to the cooling supply air temperature setpoint.

F. A2L Refrigerant Leak Detection Mode:
1. Shall be initiated as follows: Automatically in response to feedback from the A2L refrigerant leak detector(s) which is/are factory-provided in the packaged unit.
2. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, the electric heating coil shall be deenergized, cooling shall be disabled, and the supply fan shall be modulated to full design speed, according to the manufacturer's controls.
3. When the A2L refrigerant leak detector(s) no longer detect refrigerant, the packaged rooftop unit shall resume normal operation unless prohibited by related faults/warnings, according to the manufacturer's controls.

G. System Shutdown - Shall be initiated as follows:
1. Manually initiated by operator through the manufacturer's controls.
2. Automatically by the manufacturer's controls according to the occupancy schedule.
3. Automatically in the event of building power failure or fire alarm.

H. System Setpoints - The setpoints shall be operator changeable and initially set as follows:
1. Supply air temperature setpoint shall be 55 degrees F.
2. Space humidity setpoint shall be 50% RH.
3. Supply air pressure setpoint shall be 1.0 inches w.g.
4. Reference enthalpy setpoint shall be 28 Btu/lbda.
5. The minimum and maximum speed signal positions shall be set by the Balancing Contractor within the fan manufacturer's limitations.
6. The maximum outside air flowrate setpoint shall be as scheduled on the Mechanical Drawings.

7. The return air CO2 limit shall be 500 ppm above the ambient CO2 reading (adjustable). This is a dynamically controlled setpoint.
8. The space pressure setpoint shall be 0.05 inches w.g.

I. Alarms - The manufacturer's controls shall generate an alarm for the following conditions:
1. Fan failure
2. General RTU failure
3. Heating/Cooling failure

3.3 DUPLEX PACKAGED SPLIT SYSTEM AIR HANDLING UNITS (CONSTANT VOLUME, SINGLE ZONE) AH-2/ACCU-2 AND AH-3/ACCU-3

A. NOTE: The sequence of operation below is a generic representation of the proprietary sequence programmed in the manufacturer's onboard controller. It is not intended to override any operations of the the manufacturer's sequence.

B. System Off - When the system is off:
1. Supply fans shall be off.
2. DX cooling shall be off.

C. Initiation of System Start-Up - The system shall be started:
1. Manually initiated by operator through the manufacturer's controls.
2. Automatically by the manufacturer's controls according to the occupancy schedule.

D. System Operation - After system start-up has been initiated the following shall occur:
1. The active HVAC unit (indoor unit AH-2 and its associated outdoor condensing unit ACCU-2 OR indoor unit AH-3 and its associated outdoor condensing unit ACCU-3) shall be selected by the manufacturer's controls for duplex operation according to run-time or schedule. The HVAC unit not selected as the active unit shall be the standby unit.
a. Note: The manufacturer's controls for indoor units AH-2 and AH-3 and their associated outdoor condensing units shall be capable of operating the two split systems as fully redundant HVAC units which rotate active and standby status and automatically switch status in the event of the failure of the active unit. This sequence will be similar to that for redundant computer room air handling (CRAH) units.
2. The supply fan of the active unit shall be started at minimum speed. After a time period defined by the manufacturer's controls, the fan shall be enabled for automatic speed control.
3. The supply fan speed shall modulate according to the manufacturer's controls to the speed setpoint associated with the design airflow, as determined by the test and balance contractor.
4. The DX cooling shall modulate according to the manufacturer's controls to maintain the space air temperature set point.
5. Economizer Control:
a. The manufacturer's economizer controls shall not be used. No economizer operation is required.

E. A2L Refrigerant Leak Detection Mode:
   1. Shall be initiated as follows: Automatically in response to feedback from the A2L refrigerant leak detector(s) which is/are factory-provided in the packaged unit.
   2. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, the electric heating coil shall be deenergized, cooling shall be disabled, and the supply fan shall be modulated to full design speed, according to the manufacturer's controls.
   3. When the A2L refrigerant leak detector(s) no longer detect refrigerant, the packaged rooftop unit shall resume normal operation unless prohibited by related faults/warnings, according to the manufacturer's controls.

F. System Active/Standby Rotation:
   1. The standby HVAC unit (indoor unit AH-2 and its associated outdoor condensing unit ACCU-2 OR indoor unit AH-3 and its associated outdoor condensing unit ACCU-3) shall be automatically rotated to active status by the manufacturer's controls for duplex operation according to run-time or schedule.
   2. The active HVAC unit (indoor unit AH-2 and its associated outdoor condensing unit ACCU-2 OR indoor unit AH-3 and its associated outdoor condensing unit ACCU-3) shall be automatically rotated to standby status by the manufacturer's controls for duplex operation according to run-time or schedule.
   3. The rotation shall occur without perceivable interruption to space cooling operation. The current active unit will not turn off until the manufactuer's controls prove that the current standby unit is operating. Should the standby fail to start, the current active unit will remain operating and an alarm or warning shall be recorded by the controls.

G. System Shutdown - Shall be initiated as follows:
   1. Manually initiated by operator through the manufacturer's controls.
   2. Automatically by the manufacturer's controls according to the occupancy schedule.
   3. Automatically in the event of building power failure or fire alarm.

H. System Setpoints - The setpoints shall be operator changeable and initially set as follows:
   1. Space air temperature setpoint shall be 68 degrees F.
   2. The minimum and maximum supply fan speed signal positions shall be set by the Balancing Contractor within the fan manufacturer's limitations.

I. Alarms - The manufacturer's controls shall generate an alarm for the following conditions:
   1. Fan failure
   2. General RTU failure
   3. Heating/Cooling failure
   4. Active/Standby rotation failure

J. Automatic Redundancy:
   1. Failure Positions - The following shall occur upon component failure or loss of power in the active HVAC unit:

a. The standby HVAC unit shall start without delay and become the active HVAC unit according to the manufacturer's controls for duplex redundant CRAH operation.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Hydronic system requirements.

B. Equipment drains and overflows.

C. Unions, flanges, mechanical couplings, and dielectric connections.

1.2 CODE AND PERMIT COMPLIANCE

A. Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that indicated shall not be substituted.

B. Contractors shall familiarize themselves with all requirements as to permits, fees, etc., and shall comply. All permits, licenses, inspections, and arrangements required for the work shall be provided by the Contractors at their expense.

C. All utilities shall be installed in accordance with utility company rules and regulations.

D. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of piping systems. Wherever practical, install piping as indicated.

1.3 REFERENCE STANDARDS

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

B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.

D. ASME B31.9 - Building Services Piping.

E. ASTM B32 - Standard Specification for Solder Metal.

F. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

G. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).

H. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

I. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings.

J. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

K. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast.

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

1.4 SUBMITTALS

A. Product Data:
   1. Include data on pipe materials, pipe fittings, valves, and accessories.
   2. Provide manufacturers catalog information.
   3. Show grooved joint couplings, fittings, valves, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.

B. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

C. Pipe pressure testing report.

D. Mechanical grooved joint couplings, fittings and specialties shall be shown on shop drawings and product submittals, and shall be specifically identified with the manufacturer’s style or series designation.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing work of the type specified in this sectionwith minimum 5 years of experience.

C. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.

D. Date stamp all castings used for coupling housings, fittings, valve bodies, etc. for quality assurance and traceability.

E. Coupling Manufacturer:
   1. Perform on-site training by factory-trained representative to the Contractor's field personnel in the proper use of grooving tools and installation of grooved joint products.
   2. Periodic job site visits by factory-trained representative to ensure best practices in grooved joint installation.

F. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

G. All grooved joint couplings, fittings and specialties shall be the products of a single manufacturer.

1. Grooving tools shall be of the same manufacturer as the grooved components.
2. All castings used for coupling housings, fittings, etc., shall be date stamped for quality assurance and traceability.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.7 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.1 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
3. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use unions to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:
1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
2. Mechanical Press Sealed Fittings: Double pressed type complying with ASME B16.22, utilizing EPDM, non toxic synthetic rubber sealing elements..

2.3 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe of 2 Inches and Less:
1. Copper Pipe: Bronze, soldered joints.

B. Pressed Fittings:
1. Copper Tube:
a. Copper and copper alloy press fitting shall conform to material requirements of ASME B16.18 or ASME 16.22 AND Performance criteria of IAPMO PS 117.
b. Sealing elements shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by the fitting manufacturer.
c. On sizes 1/2" to 4" the fitting shall have a feature that assures leakage of liquids and/or gases from inside the system past the sealed elementof an unpressed connection. this function feature shall provide an easy indication of an unsealed connection.

C. Dielectric Connections:
1. **Dielectric unions shall not be used.**
2. Waterways and Nipples:
a. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F
3. Flanges:
a. Dielectric flanges with same pressure ratings as standard flanges.
b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
c. Dry insulation barrier able to withstand 600-volt breakdown test.
d. Construct of galvanized steel with threaded end connections to match connecting piping.
e. Suitable for the required operating pressures and temperatures.
f. Dielectric-Flange Insulation 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.
4. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degrees F.

D. Joining Materials:
1. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
2. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment using jointing system specified.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 INSTALLATION

A. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

B. Install and support in accordance with manufacturer's instructions.

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and to avoid interference with use of space.

E. Group piping whenever practical at common elevations.

F. Sleeve pipe passing through partitions, walls, and floors.

G. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.

H. Slope piping and arrange to drain at low points.

I. Anchor piping for proper direction of expansion and contraction.

J. Piping shall be installed so as to allow removal of ceiling hung equipment.

K. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. See Section 23 07 19.

3.3 EQUIPMENT DRAINS AND OVERFLOW

A. Piping material shall be suitable for type and temperature of drainage and location of equipment. Size piping per manufacturer's requirements and as indicated.

B. Cooling coil condensate drainage shall be copper pipe. Condensate drain piping size (unless indicated otherwise):
   1. Terminal Cooling, Fan Coil, Blower Coil and Furnaces:
      a. 0 - 5 tons: 3/4"
      b. 6 - 20 tons: 1"

C. Route drains and overflows to nearest floor drain unless shown otherwise. Slope piping to drain at 1/8 inch per foot. Avoid crossing walking paths in mechanical rooms.

3.4 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Piping.

B. Refrigerant.

1.2 CODE AND PERMIT COMPLIANCE

A. Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that shown on the Drawings shall not be substituted.

B. Contractors shall familiarize themselves with all requirements as to permits, fees, etc., and shall comply. All permits, licenses, inspections, and arrangements required for the work shall be provided by the Contractors at their expense.

C. All utilities shall be installed in accordance with utility company rules and regulations.

D. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of piping systems. Wherever practical, install piping as indicated.

E. AHRI 730 (I-P) - Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers.

F. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.

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

H. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.

I. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.

J. ASME B31.9 - Building Services Piping.

K. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

L. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

M. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.

N. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

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

P. MSS SP-69 - Pipe Hangers and Supports - Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.

Q. MSS SP-89 - Pipe Hangers and Supports - Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.

1.3 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Product Data: Provide general assembly of specialties, including manufacturer's catalogue information. Provide manufacturer's catalog data including load capacity.

C. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.

D. Design Data: Submit design data indicating pipe sizing. Indicate load-carrying capacity of trapeze, multiple pipe, and riser support hangers.

E. Test Reports: Indicate results of leak test, acid test.

F. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.

G. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.

H. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Extra Filter-Dryer Core: One spare for each filter-dryer assembly.

1.4 QUALITY ASSURANCE

A. Designer Qualifications: Design piping system under direct supervision of a Professional Engineer experienced in design of this type of work.

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties in shipping containers with labeling in place.

B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Comply with ASME B31.9 for installation of piping system.

B. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.

C. Welders Certification: In accordance with ASME BPVC-IX.

D. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

2.2 PIPING

A. Copper Tube: ASTM B280, H58 hard drawn.
   1. Fittings: ASME B16.22 wrought copper.
   2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

B. Pipe Supports and Anchors:
   1. Provide hangers and supports that comply with MSS SP-58.
      a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
   2. Conform to ASME B31.5.
   3. Hangers for Pipe Sizes 1/2 to 1-5/8 Inch: Carbon steel adjustable swivel, split ring.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
   6. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
   7. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
   8. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
      a. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
      b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
      c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.

e. Height: Provide minimum clearance of 18 inches under pipe to top of roofing.

f. Manufacturers:

1) Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.

2) Erico International Corporation: www.erico.com.

3) PHP Systems/Design: www.phpsd.com.

4) Unistrut, a brand of Atkore International Inc: www.unistrut.com.

2.3 REFRIGERANT

A. Refrigerant: R-454B, as defined in ASHRAE Standard 34.

B. Refrigerant: R-32, as defined in ASHRAE Standard 34.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instructions.

B. Size refrigerant piping per the condensing unit manufacturer's recommendations.

C. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and avoid interference with use of space.

E. Group piping whenever practical at common elevations and locations. Slope piping in the direction of refrigerant flow as recommended by the condensing unit manufacturer.

F. Do not install riser traps in refrigerant piping unless specifically required by the condensing unit manufacturer.

G. Do not install double suction risers unless specifically required by the condensing unit manufacturer.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Provide clearance for installation of insulation and access to valves and fittings.

J. Flood piping system with nitrogen when brazing.

K. Insulate piping; refer to Section 230719 .

L. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.

M. Fully charge completed system with refrigerant after testing.

3.3 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ASME B31.5.

3.4 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.

3.5 ADJUSTING

A. Adjust set-point temperature of the conditioned air controllers to the system design temperature.

B. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

3.6 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter-dryer after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION

SECTION 23 31 00

HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Metal ducts.

B. Flexible ducts.

1.2 DEFINITIONS

A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C168. In this Section, these values are the result of the formula Btu x in./h x sq. ft. x deg F or W/m x K at the temperature differences specified. Values are expressed as Btu or W.
   1. Example: Apparent Thermal Conductivity (k-Value): 0.25 or 0.037.

B. Pressure - Velocity Classification for Ductwork: As defined by SMACNA Duct Construction Standards - Metal and Flexible (latest edition), and applicable codes. Pressure classification for this specification:
   1. Low Pressure: Maximum 2500 FPM velocity; maximum 2.0 inches WG positive or -2.0 inches WG negative static pressure class.
   2. Medium Pressure: Maximum 4000 FPM velocity; maximum 4 inches WG positive or -3.0 inches WG or greater negative static pressure class.
   3. High Pressure: Velocity over 4000 FPM, pressure over 4 inches WG.

C. Gauge:
   1. Steel Sheet: U.S. Standard gauge.
   2. Aluminum Sheet: Brown & Sharpe schedule.
   3. Steel Wire: Washburn & Moen gauge.

D. Concealed Insulated Surfaces: Ductwork and equipment located in walls, partitions, floors, chases, shafts, and above ceilings.

E. Exposed Insulated Surfaces: Ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

1.3 REFERENCE STANDARDS

A. 29 CFR 1910.146 - Permit-Required Confined Spaces.

B. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.

C. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

G. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

I. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

1.4 PERFORMANCE REQUIREMENTS

A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Design Professional. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

B. Size round ducts in lieu of rectangular ducts indicated in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.5 SUBMITTALS

A. Product Data: Provide data for all duct materials, duct liner, and duct connections.

B. Manufacturer's Installation Instructions: Indicate special procedures for glass fiber ducts.

C. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of documented experience.

C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

D. Comply with ASHRAE and SMACNA Design Handbooks.

1.7 FIELD CONDITIONS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures within acceptable range during and after installation of duct sealants.

1.8 DELIVERY, STORAGE AND HANDLING

A. Ductwork shall not be stored directly on the ground. Watermarked ductwork will not be accepted for installation.

B. Lined ductwork shall have all open ends sealed during delivery and storage periods.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Provide UL Class 1 ductwork, fittings, hangers, supports, and appurtenances in accordance with NFPA 90A and SMACNA (DCS) guidelines unless stated otherwise.

B. Acoustical Treatment: Provide sound-absorbing liners and sectional silencers for metal-based ducts in compliance with Section 23 33 19.

C. Duct Shape and Material in accordance with Allowed Static Pressure Range:
1. Round: Plus or minus 2 in-wc of galvanized steel.
2. Rectangular: Plus or minus 1/2 in-wc of galvanized steel.
3. Flat Oval: Plus 2 in-wc of galvanized steel.

D. Duct Sealing and Leakage in accordance with Static Pressure Class:
1. Duct Pressure Class and Material for Common Mechanical Ventilation Applications:
a. Low Pressure Supply: 1 inch w.g. pressure class, galvanized steel.
b. Return and Relief Air: 1 in-wc pressure class, galvanized steel.

E. Duct Fabrication Requirements:
1. Duct and Fitting Fabrication and Support: SMACNA (DCS) including specifics for continuously welded round and oval duct fittings.
2. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
3. Use reinforced and sealed sheet-metal materials at recommended gauges for indicated operating pressures or pressure class.
4. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide airfoil turning vanes of perforated metal with glass fiber insulation.
5. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.

6. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
7. Provide turning vanes of perforated metal with glass fiber insulation when an acoustical lining is required.
8. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.2 MATERIALS

A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, FS Type B, with G90/Z275 coating.
   1. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
   1. Type: Water based, non-fibrated, heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
   2. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.
   3. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   4. Duct Sealing Rolled Sealant:
      a. Pressure sensitive, 40-year cycle, duct joint and general purpose rolled sealant. rated for use with sheet metal, duct board, flex board, PVC coated duct, and duct wrap vapor barriers.
      b. 100 percent solid elastomeric modified butyl with aluminum foil backing.
      c. Thickness: 17 Mils.
   5. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
   6. Flange and Joint Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel, threaded steel rod or steel cable with adjustable and removable locking mechanism.
   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap, Rod and Cable Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and steel rod diameters. Comply with SMACNA and manufacturer's recomendations for cable and locking mechanism sizes.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Cable Hanger System:
   1. Basis of Design: Gripple and Ductmate Clincher
   2. Products shall carry a 5:1 safety factor.
   3. SMACNA compliance - Tested and verified to be an acceptable hanger per the SMACNA, HVAC Duct Construction Standards.
   4. UL Listing - UL 1598 luminaire fitting sizes 1 - 5, UL 2289 Conduit and Cable Hardware sizes 2, 3 and 4.
   5. Housing: Type ZA2 Zinc.
   6. Wedge: Sintered steel hardened to min. 56 Rockwell C.
   7. Spring: 302 Stainless Steel.
   8. End Cap: UV stabilised homopolymer propylene.
   9. Wire Rope: Grade galvanized high tensile steel wire rope to EN12385.
   10. Toggle Plate and End Stop: Zinc plated steel.
   11. Stud Eyelet and Barrel End: Zinc plated steel.

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
   3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

F. Flexible Duct Elbow Supports:
   1. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.
   2. Classified: UL 2043.
   3. Material: 100 percent recycled copolymer polypropylene.
   4. Support Frame Radius: 8 inches.
   5. Compliance for Flexible Duct Radius:
      a. SMACNA HVAC Duct Construction Standards.
      b. ASHRAE Advanced Energy Design Guides.
      c. ADC Flexible Duct Performance and Installation Standards.
   6. Basis of Design: FlexRight (Durable Elbow Support)

2.4 DUCTWORK FABRICATION

A. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation. Radius T's, bends and elbows less than 1-1/2 times width of duct on centerline are not allowed.

B. Low Pressure Ductwork: Construct all ductwork using galvanized steel except as indicated.
   1. Seams and Joints: Longitudinal seams shall be grooved seams, button punch snap lock or Pittsburgh lock. Transverse joints shall be drive slip. Joints 36-inch size and larger shall be manufactured duct joining system with downset corners, no-bolt design, or SMACNA T-25 formed on flanges with corner and cleat. Contractor option on smaller sizes.

C. Branch ducts to air devices shall be bell-mouth, conical or 45 degrees to round boot type fitting as a basis. Straight tap-ins, splitter dampers, and air extractors shall not be used.

D. Duct connections to fans/air-handling units shall be designed for proper entering and leaving conditions at the fan to avoid any adverse system effect fan losses.

2.5 MANUFACTURED DUCTWORK, FITTINGS AND CONNECTORS

A. Manufacturers:
   1. Ductmate Industries, Inc.:
   2. Eastern Sheet Metal.
   3. KB Duct
   4. LaPine Metal Products
   5. Lewis and Lambert
   6. Linx Industries
   7. Metal-Fab, Inc.: www.mtlfab.com.
   8. MKT Metal Manufacturing: www.mktduct.com/#sle.
   9. Nexus Inc.
   10. Norlock
   11. SEMCO Incorporated: www.semcoinc.com.
   12. S.E.T. Duct Manufacturing
   13. Sheet Metal Connectors.
   14. United McGill Corp.: www.unitedmcgill.com.
   15. Ward Industries, Inc.

B. Material Requirements:
   1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.

C. Rectangular Metal Duct:
   1. Rectangular Double Wall Insulated: Rectangular longitudinal seam duct with galvanized steel outer wall.

D. Round Metal Ducts:

1. Round Single Wall Duct: Round lock seam duct with galvanized steel outer wall.

E. Round Spiral Duct:
1. Round spiral lock seam duct with galvanized steel outer wall.

F. Connectors, Fittings, Sealants, and Miscellaneous:
1. Fittings: Manufacture with solid inner wall of perforated galvanized steel.
2. Transverse Duct Connection System: SMACNA "E" rated rigid class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips in accordance with SMACNA (DCS).
3. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
   a. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
   b. VOC Content: Not more than 250 g/L, excluding water.
   c. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
   d. For Use with Flexible Ducts: UL labeled.
4. Gasket Tape:
   a. Provide butyl rubber gasket tape for a flexible seal between transfer duct connector (TDC), transverse duct flange (TDF), applied flange connections, and angle ring connections.

2.6 FLEXIBLE DUCTS

A. Vapor Barrier Insulated Flexible Air Ducts:
1. UL 181, Class 1, two-ply polyester or vinyl film supported by helically wound spring steel wire.
2. Insulation: Fiberglass insulation with polyethylene vapor barrier core.
3. Pressure Rating: From 10 in-wc positive to 1 in-wc negative.
4. Maximum Velocity: 4,000 fpm.
5. Temperature Range: Minus 10 to 160 degrees F.

2.7 DUCT LINER

A. Refer to Section 23 0713 - Duct Insulation.

PART 3 EXECUTION

3.1 PRE-INSTALLATION

A. Field measure to determine exact conditions.

B. Provide duct opening closure film on all ductwork until final connections are completed.

C. Verify location of air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to reflected ceiling plans, finish schedule, material finish specification, and shop drawings.

D. Openings required for ductwork through structural elements in new construction shall be coordinated with the General Contractor. Shop drawings locating such openings shall be prepared in ample time to meet the construction schedule.

E. Coordinate and install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install ducts with a clearance of 2 inches, plus allowance for insulation thickness.

F. Coordination Process:

1. Provide coordination in determining adequate clearance and space requirements for mechanical equipment and electrical equipment and other items/equipment in the project. The Design Professional reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Design Professional will only review conflicts and given an opinion but will not perform as a coordinator.
    a. The coordination process shall utilize the actual equipment being provided. Refer to manufacturer's data for physical size, access and maintenance requirements. Provide all code required clearances.
2. Equipment layout and all system layouts shall confirm adequate clearances for installation, operation, maintenance, and code-required clearances from the structure or other equipment and systems. Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
3. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Design Professional.
4. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings. Access to mechanical and electrical items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Design Professional at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.
5. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.
6. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:
    a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.
    b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.

c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.

7. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Design Professional and the Owner for review on a monthly basis with changes “clouded” and brought to the attention of the Design Professional and the Owner.
8. When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Design Professional revisions necessary to the work of others not directly affected by the change order.
9. Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.

3.2 INSTALLATION

A. Install, support, and seal ducts in accordance with SMACNA (DCS).
   1. Hanging, Sealing and Supporting:
      a. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
      b. Support vertical ducts at a maximum interval of 16 feet and at each floor.
      c. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
      d. Install concrete inserts before placing concrete.
      e. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
         1) Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
      f. Seal ducts before external insulation is applied.

B. Install products following the manufacturer's instructions.

C. Comply with safety standards NFPA 90A and NFPA 90B.

D. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Keep openings covered until ready for continuing duct run or final connections. Clean all unlined supply air ductwork during installation by swabbing with a non-toxic, non-flammable cleaning agent.

E. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

F. Provide volume dampers in all branch take-offs connecting to diffusers, registers and grilles, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
   1. Registers and diffusers with dampers shall be used only if devices are installed directly on the trunk duct.

G. Flexible Ducts: Connect to metal ducts with draw bands.
   1. Flexible ductwork shall be attached to metal collars or sleeves with draw bands. Duct adhesive shall be added to connections as required per duct system sealing class. Metal collars or sleeves 12 inches and larger shall contain draw band holding beads.
   2. Low Pressure Ductwork: Peel back vapor barrier and fold back insulation; then secure to duct collar or sleeve with metal or nylon clamps or draw bands; then fold over insulation and vapor barrier and secure with two stretched wraps of approved cut tape.
   3. Support flexible ductwork following manufacturer's recommendations and SMACNA HVAC Duct Construction Standards.
   4. Final connections to air inlets and outlets may be made with flexible ductwork. Expanded length of flexible ductwork shall not exceed 36 inches. Path of flexible ductwork shall not exceed 45 degrees unless flexible duct elbow supports are provided.
   5. Flexible Duct Elbow Supports:
      a. Install flexible duct elbow supports in accordance with manufacturer's instructions.
      b. Install flexible duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions.
      c. Install flexible duct elbow supports at flexible duct 90-degree bends at following locations:
         1) Diffusers.
         2) Grilles.
         3) Registers.
         4) Duct take-offs and taps.
         5) Air devices with round inlets and outlets.
         6) HVAC equipment with round inlets and outlets.
         7) As indicated.

H. Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.

I. Provide openings in ductwork as indicated to accommodate thermometers and controllers. Provide pilot tube openings as indicated for testing of systems, complete with metal can with spring device or screw to insure against air leakage. For openings, insulate ductwork and install insulation material inside a metal ring.

J. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

K. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with a crimp in the direction of airflow.

L. Use double nuts and flat washer on threaded rod supports.

M. Louver Fit-out:
   1. Provide blank-out panels sealing available area of wall-mounted exterior-faced louver when connected ductwork is smaller than actual louver free area, and duct outlet is smaller than the louver frame.
   2. Use the same duct material painted black on the exterior side, then seal louver frame and duct.

N. Penetrations:
   1. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.
   2. Provide sleeves at all duct penetrations through walls, floors and roofs. Openings through sound-rated partitions shall have annular space stuffed with fiberglass insulation for full thickness of wall.
   3. Provide closure flanges around exposed ductwork at wall and ceiling penetrations, 1-1/4 inches wide minimum.

O. Install round and flat-oval ducts in lengths not less than 12 feet, unless interrupted by fittings.

P. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

Q. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

R. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

S. Prevent passage of unfiltered air around filters with felt, rubber, neoprene gaskets, or other approved safing material.

END OF SECTION

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air turning devices.

B. Duct access doors.

C. Duct test holes.

D. Volume control dampers.

E. Miscellaneous Products:
1. Internal strut end plugs.
2. Duct opening closure film.

F. Duct accessory hardware.

G. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

I. UL 555 - Standard for Fire Dampers.

J. UL 555S - Standard for Smoke Dampers.

1.2 SUBMITTALS

A. Product Data: Provide for shop-fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used. Include electrical characteristics and connection requirements.

B. Shop Drawings: Indicate for shop and field fabricated assemblies including volume control dampers and duct access doors.
1. Special fittings.
2. Motorized-control damper installations.
3. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer's Installation Instructions: Provide instructions for fire dampers, combination fire and smoke dampers, and smoke dampers.

D. Project Record Drawings: Record actual locations of access doors and test holes.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Fusible Links: One of each type and size.

F. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

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

PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Access Doors, Devices and Accessories:
1. Acudor Products Inc: www.acudor.com.
2. Carlisle HVAC Products: www.carlislehvac.com/sle.
3. Ductmate Industries, Inc.
4. Elgen Manufacturing: www.elgenmfg.com.
5. Flexmaster U.S.A., Inc.
6. Greenheck: www.greenheck.com
7. Krueger: www.krueger-hvac.com.
8. Lloyd Industries, Inc.: www.firedamper.com.
9. Nailor Industries Inc: www.nailor.com.
10. PCI Industries, Inc; Pottorff Brand [<>]: www.portorff.com.
11. Ruskin Company: www.ruskin.com.
12. SEMCO Incorporated: www.semcohvac.com.
13. Titus: www.titus-hvac.com.
14. United Enertech
15. Ventfabrics, Inc.
16. Vent Products Company, Inc.
17. Young Regulator Co
18. Ward Industries, Inc: www.wardind.com.

B. Dampers:
1. Air Balance, Inc.
2. Greenheck: www.greenheck.com
3. Louvers & Dampers, Inc: www.louvers-dampers.com.
4. Lloyd Industries, Inc.[<>]: www.firedamper.com.
5. Nailor Industries Inc[<>]: www.nailor.com.
6. NCA Manufacturing, Inc.: www.ncamfg.com
7. Pottorff/PCI Industries, Inc; Pottorff Brand : www.portorff.com.
8. Rossi: www.rossihardware.com
9. Ruskin Company: www.ruskin.com.
10. Tamco
11. United Enertech: www.unitedenertech.com/#sle.
12. Vent Products Company, Inc.
13. Ward Industries, Inc: www.wardind.com.

C. See paragraphs below for additional manufacturers.

2.2 SHEET METAL MATERIALS

A. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

B. Stainless Steel: ASTM A 480/A 480M.

C. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 AIR TURNING DEVICES

A. Multi-blade device with blades aligned in short dimension; steel construction; with individually and mounting straps.

2.4 DUCT ACCESS DOORS

A. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ducts, install minimum 1-inch thick insulation with sheet metal cover.
   1. Less Than 12 inches Square: Secure with sash locks.
   2. Up to 18 inches Square: Provide two hinges and two sash locks.
   3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
   4. Larger Sizes: Provide an additional hinge.
   5. Access doors shall be provided with sash locks only when clearance space does not allow a door swing.

B. Access doors with sheet metal screw fasteners are not acceptable.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with foam insulation fill and 1-inch thickness.
   1. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.
   1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.5 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.6 VOLUME CONTROL/BALANCING DAMPERS

A. Fabricate in accordance with SMACNA (DCS) and as indicated.

B. Single Blade Dampers:
1. Fabricate for duct sizes up to 6 by 30 inch.
2. Blade: 24 gauge, 0.0239 inch, minimum.

C. Multi-Blade Damper: Fabricate consisting of opposed blades with maximum blade sizes 8 by 72 inches. Assemble center- and edge-crimped blades in prime-coated or galvanized-channel frame with suitable hardware.
1. Blade: 18 gauge, 0.0478 inch, minimum.

D. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

E. Quadrants:
1. Provide positive-locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches provide regulator at both ends.

2.7 MISCELLANEOUS PRODUCTS

A. Internal Strut End Plugs: Combination end-mounting and sealing plugs for metal conduit used as internal reinforcement struts for metal ducts; plug crimped inside conduit with outside gasketed washer seal.

B. Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction.
1. Thickness: 2 mils.
2. High tack water based adhesive.
3. UV stable light blue color.
4. Elongation Before Break: 325 percent, minimum.

C. Jackshaft: 1-inch-diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). See Section 23 31 00 for duct construction and pressure class.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Provide duct test holes where indicated and required for testing and balancing purposes.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum two duct widths from duct take-off.

E. Provide volume control (balancing) dampers on duct take-off to all air inlets and outlets, diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

F. Provide volume control (balancing) dampers in all duct systems where indicated and required to perform complete system test and balance. Coordinate all volume damper locations with the test and balance contractor.

G. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

H. Provide turning vanes in all mitered duct turns.

I. Provide filter gage for each filter bank.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual-volume dampers is specified in Section 23 0593 - Testing, Adjusting, and Balancing.

3.3 DEMONSTRATION

A. Demonstrate the following to the owner's representative and maintenance personnel:
1. Access to all volume damper position controls.

END OF SECTION

SECTION 23 81 26.13

SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air cooled condensing units.

B. Indoor air handling (fan and coil) units for ducted systems.

C. Controls.

1.2 REFERENCE STANDARDS

A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

B. AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment.

C. AHRI 520 - Performance Rating of Positive Displacement Condensing Units.

D. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.

E. ASHRAE Std 23 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units.

F. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.

G. ASHRAE Std 90.2 - High-Performance Energy Design of Residential Buildings.

H. ASHRAE Std 103 - Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers.

I. NEMA MG 00001 - Motors and Generators.

J. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

K. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical.

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

1.3 SUBMITTALS

A. Specification Compliance Review.

B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.

D. Design Data: Indicate refrigerant pipe sizing.

E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.

F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

G. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Filters: One for each unit.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years of experience and approved by manufacturer.

1.5 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases.

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations.

1.6 WARRANTY

A. Provide four year manufacturer's parts warranty for compressors.

B. Provide one year parts and labor warranty on entire unit.

PART 2 PRODUCTS

2.1 MANUFACTURERS - HEATING AND COOLING

A. AboveAir Technologies: www.aboveair.com

B. Innovent: www.innoventair.com

C. Trane: www.trane.com

D. Other if approved in writing by the Engineer during the project bid period.

2.2 SYSTEM DESIGN

A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
   1. Heating: Electric resistance heating, where indicated. See Mechanical drawings.
   2. Cooling: Outdoor electric condensing unit with evaporator coil in central ducted indoor unit.
   3. Provide refrigerant lines internal to units and between indoor and outdoor units according to the requirements of Section .
   4. Provide trapped coil condensate piping between indoor unit evaporator drain plan and terminate where indicated on the mechanical plans.

B. Performance Requirements: See Drawings for Equipment Schedule.
   1. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 26 05 83.

2.3 INDOOR AIR HANDLING UNITS FOR DUCTED SYSTEMS

A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
   1. Air Flow Configuration: Horizontal.
   2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
   3. Control: Single zone, variable air volume.

B. Refrigerant: R-454B or R-32, listed to UL Standard 60335-2-40, with a factory-installed A2L refrigerant leak detection system, as required by the UL standard.

C. Supply Fan: Direct drive, backward inclined impeller.

D. Motor: Electrically Commutated Motor (ECM)
   1. Synchronous rotation. Variable speed direct current brushless. Permanent magnet.
   2. Permanently lubricated ball bearings.
   3. Integrated controller/inverter operates the wound stator and senses rotor position to electronically commutate the stator. Soft start and soft speed change ramps.
   4. Starting Torque: Exceeding one fourth of full load torque.
   5. Breakdown Torque: Approximately 250 percent of full load torque.
   6. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor.

E. Air Filters:
   1. 4" MERV 13 pleated disposable air filter, where indicated. See Mechanical drawings.

2. 4" MERV 8 pleated disposable air filter, where indicated. See Mechanical drawings.

F. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
2. Manufacturers: System manufacturer.

G. Electric Heat (AH-1 Only):
1. Stainless steel contruction.
2. SCR controlled.
3. Reheat/heat operation.

H. Outside Air Control (AH-1 Only):
1. Manufacturer provided remote mixing box with outside air and return air dampers modulated according to the manufacturer's space CO2-based demand controlled ventilation sequence of operation.
2. Manufacturer furnished space CO2 sensor.

2.4 OUTDOOR UNITS

A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
1. Comply with AHRI 210/240.
2. Refrigerant: R-454B or R-32, listed to UL Standard 60335-2-40, with a factory-installed A2L refrigerant leak detection system, as required by the UL standard.
3. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
4. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL 207.
5. Sound Rating: 69 dBA, when measured in accordance with AHRI 270 (SI/I-P).

B. Compressor: Scroll, modulating digital control 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with low ambient control down to -20 deg F. Provide time delay control to prevent short cycling.

C. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
1. Condenser Fans: Direct-drive propeller type, variable speed.
2. Condenser Fan Motor: Enclosed, 1-phase type, permanently lubricated.
3. Cottonwood/Hail Guard Coil Filter Screening:
a. Engineered HVAC Mesh
b. Non-porous, UV resistant, vinyl coated polyester media w/non-stick surface.
1) Flame resistant (self-extinguishing)
2) Low debris adhesion
3) Mold and mildew resistant.

c. 1.125” heavy duty fiber reinforced outer binding.
1) Quick release nylon twist-lock fasteners.
d. Low air resistance and static pressure impact
e. Provide with Hail-Proof backing mesh w/aluminum mounting track.

D. Coil: Air-cooled, aluminum fins bonded to copper tubes.

E. Accessories: Filter drier, high-pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
1. Provide thermostatic expansion valves.

F. Mounting: See mechanical drawings.

2.5 OPERATING CONTROLS

A. AH-1/ACCU-1
1. Control by manufacturer provided room thermostat to maintain room temperature setting by manufacturer's single zone variable air volume control sequence.
2. Ventilation shall be controlled by the manufacturer's space CO2 based demand controlled ventilation sequence using manufacturer provided CO2 sensor and outside air and return air control dampers.
3. See Specification Section 23 09 93 - Sequence of Operations for HVAC Controls for additional information.

B. AH-2/ACCU-2 and AH-3/ACCU-3
1. Control each unit by a manufacturer provided room thermostat to maintain room temperature setting by manufacturer's single zone constant air volume control sequence.
2. The manufacturer's controls for indoor units AH-2 and AH-3 and their associated outdoor condensing units shall be capable of operating the two split systems as fully redundant HVAC units which rotate active and standby status and automatically switch status in the event of the failure of the active unit. This sequence will be similar to that for redundant computer room air handling (CRAH) units.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.

B. Verify that proper power supply is available and in correct location.

C. Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.

B. Install in accordance with NFPA 90A.

C. Install refrigeration systems in accordance with ASHRAE Std 15.

D. Install units level and plumb.

E. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

F. Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

G. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

H. Provide trapped coil condensate piping between indoor unit evaporator drain plan and terminte over nearest floor drain.

3.3 CONNECTIONS

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

B. Refrigerant Piping: As specified elsewhere in the mechanical drawings and specifications. Size per the split system manufacturer's recommendations.

C. Install piping adjacent to unit to allow service and maintenance.

D. Provide trapped coil condensate piping between indoor unit evaporator drain plan and terminate where indicated on the mechanical plans.

E. Duct Connections: As specified elsewhere in the mechanical drawings and specifications.

F. Ground equipment according to the electrical drawings and specifications.

G. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

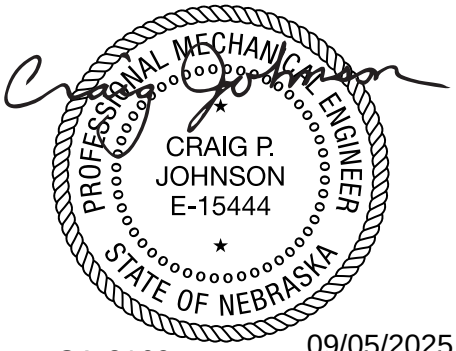
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

END OF SECTION



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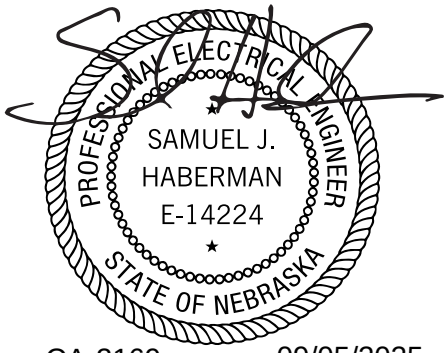

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SECTION 26 04 00

COMMON REQUIREMENTS FOR ELECTRICAL

PART 1 GENERAL

1.1 SUMMARY

A. This section describes the general requirements of these specifications and shall apply to all phases of the work specified, shown on the drawings, or required to provide for complete installation of all systems for this project.

B. This Section includes basic materials and methods to complement other Division 26 Sections.

C. This Section includes basic materials and methods to complement Section 28 46 00 - Fire Detection and Alarm.

1.2 WARRANTIES

A. Warrant materials, workmanship and equipment against defects for a period of one year after the date of substantial completion.

B. Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those divisions of the Project Manual.

C. Repair or replace, at no additional cost to the Owner, any item which may become defective within the warranty period.

D. Any manufacturers' warranties concerning any item installed will run to the benefit of the Owner.

E. The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project.

F. The repair of faulty workmanship shall be considered to be included in the contract.

1.3 ALTERNATES

A. Alternates, if required, shall be as described in the “Alternates” section of this Project Manual, as described on the proposal form, or as indicated on the drawings.

1.4 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Engineer for clarification.

B. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date.

C. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.

D. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

E. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, request clarification from the Engineer before proceeding with the work.

B. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Engineer.

C. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Engineer was requested and obtained before submission of proposed methods or materials.

D. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.6 DEFINITIONS

A. The following definitions shall apply throughout the contract documents:
   1. Engineer: Architect or Engineer
   2. Code: Applicable national, state and local codes
   3. Mechanical: Plumbing, HVAC, and Fire Protection work required by the Contract Documents
   4. Electrical: Electrical and Fire Alarm work required by the Contract Documents
   5. Contractor: Any Contractor performing work required by the Contract Documents
   6. Indicated: Noted, scheduled or specified
   7. Selected: Selected by the Engineer.
   8. Provide: Furnish, install, connect and tested complete and ready for use
   9. Furnish: Supply and deliver to the site ready for installation
   10. Install: Install complete, per Contract Documents and manufacturer's requirements.
   11. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
   12. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
   13. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

14. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
15. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
16. Dry Locations: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
17. Damp Locations: Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.
    a. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.
18. Wet Locations: Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

1.7 SYMBOLS

A. Items of equipment and materials are indicated on the drawings in accordance with the symbols on the plans.

1.8 ABBREVIATIONS

A. Refer to abbreviations list on the Drawings.

B. The following abbreviations apply throughout the Contract Documents:
1. ADA: Americans with Disabilities Act
2. ANSI: American National Standards Institute
3. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers
4. ASME: American Society of Mechanical Engineers
5. ASTM Specification: Standard specifications of the American Society for Testing Materials
6. FM: Factory Mutual Engineering Corporation
7. IRI: Industrial Risk Insurers
8. NEC: National Electrical Code, latest edition
9. NEMA: National Electrical Manufacturers Association
10. NFPA: National Fire Protection Association
11. UL or Underwriters: Underwriters Laboratories, Inc.

1.9 CODES

A. The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.

B. The work shall conform to all applicable sections of currently adopted editions of the following codes, standards, and specifications:
   1. International Building Code (IBC)
   2. International Fire Code (IFC)
   3. International Energy Conservation Code (IECC)
   4. Safety and Health Regulations for Construction
   5. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
   6. National Electrical Code (NEC)
   7. National Electrical Safety Code (NESC)
   8. National Fire Protection Association (NFPA)
   9. Life Safety Code (NFPA 101)
   10. Factory Mutual Global Engineering (FMG)
   11. Underwriters' Laboratories, Inc. (UL)
   12. National Electrical Manufacturers Association (NEMA)
   13. Institute of Electrical and Electronics Engineers (IEEE)
   14. Insulated Power Cable Engineers Association (IPCEA)
   15. Telecommunications Industry Association (TIA)
   16. Building Industry Consulting Service International (BICSI)
   17. Applicable national, state and local codes

C. Where there is a conflict between the code and the Contract Documents, the code shall have precedence only when it is more stringent than the Contract Documents.
   1. Items that are allowed by the code but are less stringent than those specified shall not be substituted.

1.10 PERMITS

A. The Contractors shall familiarize themselves with requirements regarding permits, fees, etc., and shall comply with them.

B. Permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.

1.11 MATERIALS AND EQUIPMENT MANUFACTURERS

A. Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.

B. Materials and equipment shall be provided in accordance with the following:
   1. Primary Design Products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
   2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.
   3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.

4. Acceptable Equivalent Substitutions: Acceptable equivalent substitutions are products of manufacturers other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:
    a. The product shall be manufactured by one of the acceptable manufacturers listed in the Project Manual, drawings, or addenda.
    b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
    c. The Contractor providing the substitution shall bear the total cost of changes due to substitutions. These costs may include additional compensation to the Engineer for redesign and evaluation services, increased cost of work by the Owner or other Contractors, and similar considerations.
5. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
6. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.

C. Proposed substitutions will be judged on the basis of quality, performance, appearance and on the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.

D. The Engineer shall be the sole and final judge as to the suitability of substitution items.

1.12 SUBMITTALS

A. Shop Drawings, Product Data and Samples:
1. Other sections in the Project Manual shall be adhered to if more stringent than the following paragraphs.
2. When required by other sections of this Project Manual, submit shop drawings, product data or samples to the Engineer for review.
3. Submittals deemed unnecessary by the Engineer shall be returned indicating “No Action Taken”.
4. A completed copy of the transmittal form included with the Project Manual shall accompany each submittal.
5. Submittals shall be numbered consecutively.
6. Unless otherwise noted, submit one copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
7. Where samples are required, submit one (1) sample of each required item.
8. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor to illustrate some portion of the work. Shop Drawings shall also detail fabrication

and installation for metal and wood supports and anchorage for mechanical materials and equipment.

a. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.

9. Product data are illustrations, standard schedules, performance charts, instruction brochures, diagrams and other information furnished by the Contractor, Manufacturer, Supplier, or Distributor to illustrate a material, product or system for some portion of the work.
10. Samples are physical examples furnished by the Contractor, Manufacturer, Supplier, or Distributor to illustrate materials, equipment or workmanship and to establish the standards by which the work will be performed.
11. Each submittal shall clearly indicate proposed items, capacities, characteristics and details in conformance with contract documents. Equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions and special features required shall be certified by the manufacturer.
12. Submittals shall indicate manufacturer's delivery time for the item after review by the Engineer.
13. The Engineer shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
14. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Engineer's review of shop drawings, product data or samples.
15. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Engineer's review of those drawings.
16. No portion of the work requiring submission of a shop drawing, product data or sample shall be commenced until the submittal has been reviewed by the Engineer. Such portions of the work shall be in accordance with reviewed submittals.
17. The successful Contractor/Supplier may, at their option, obtain DXF or AutoCad DWG electronic drawing files for use in preparation of shop drawings.
    a. This information is available from Alvine upon written request.
    b. A non-refundable handling charge of $10.00 per drawing file requested will be required at the time of receipt of the electronic files.
    c. The use of these drawing files is intended solely for the preparation of drawings as required by these contract documents.
    d. Any other use is strictly prohibited by copyright laws.
    e. The user of these electronic drawing files assumes full responsibility for their accuracy and scale.

B. Operation and Maintenance Manuals:

1. Prepare three (3) operation and maintenance manuals for the equipment furnished. Manuals shall be submitted to the Engineer for review and distribution to the Owner not less than 30 days prior to substantial completion of the project. Manuals not meeting the following requirements may be rejected by the Engineer.

2. Each manual shall be assembled in a three-ring binder with hard cover and plastic finish. Binders shall not exceed a 3-inch thickness. Where more than one binder is required, the manuals shall be separated into a logical grouping, i.e., “Mechanical”, “Electrical”, “Maintenance”, “Operation”, “Parts”, Shop Drawings”, etc. Each binder shall have the following information clearly printed on its front cover:
    a. Project name and address.
    b. Portion of the work covered by each volume (if more than one volume in the set). Where more than one volume is required, label each volume as “Volume _____ of _____”.
    c. Name, address and telephone number of Contractor and Sub-Contractors including night or emergency number.
3. Manual shall include, but shall not be limited to, the following:
    a. A Complete Index. Contractor may submit the index to the Engineer for review prior to submittal of complete manuals if desired.
    b. Names, Addresses and Telephone Numbers. This list shall include the manufacturer and local representative who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the binder.
    c. Startup, Operation and Shutdown Procedures. Provide a written description of procedures for startup, operation and shutdown of each electrical item or system. This description shall include switches to operate, buttons to push, etc., in proper sequence, and the location of switches, starters, and pushbuttons. Description shall include item references or labels used in the contract documents unless otherwise instructed in advance by the Owner.
    d. Equipment Accessory Schedule. Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required and the manufacturer of renewable items.
    e. Manufacturer's Operation and Maintenance Manuals and Parts Lists.
    f. Emergency Procedures. Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.
    g. One copy of shop drawings and product data, clearly marked for each item furnished using the designation label specified or indicated on Drawings.
    h. Manufacturers' warranty information.
    i. Normal Maintenance Schedule. Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days and yearly.

1.13 OPERATING TRAINING

A. Complete operating instructions for each system and item of equipment shall be provided to the Owner's designated personnel.

B. Operation and Maintenance Manuals must be reviewed and accepted by the Engineer and provided to the Owner prior to operating training.

C. Training shall be scheduled at the convenience of the Owner. A minimum of 2 hours of training shall be provided.

D. Training shall include instructions on the following:
   1. Startup and shutdown procedures
   2. Periodic maintenance
   3. Emergency operation
   4. Safety

E. In addition to the instructions required above, wherever possible perform the operations being described in order to fully illustrate system operation.

F. At the completion of training, turn over to the Owner required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.

1.14 QUALITY ASSURANCE

A. Conform to the requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.15 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment.
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
   1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

C. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work.

D. Coordinate electrical service connections to components furnished by utility companies.
   1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
   2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

E. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces.

F. Coordinate electrical testing of electrical, mechanical, or architectural items so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

G. Provide offsets and elevation changes in conduit and cable tray as required to complete the Layout and Coordination Process.

1.16 STRUCTURAL COORDINATION

A. In cases where the Contractor determines that superimposed loads such as suspended or floor mounted electrical system or equipment exist which exceed design loads indicated on structural contract documents, Contractor shall submit load data to Engineer for review prior to proceeding with work.

B. Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc. over the member's tributary area in a way that the design superimposed dead loads listed in structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.

C. Connections of systems designed by Contractor's engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Equipment Schedules for Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 EQUIPMENT SHORT CIRCUIT CURRENT RATING

A. Where the National Electrical Code or applicable codes require equipment to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment. Acceptable methods of complying with this requirement are as follows:
   1. Provide SCCR rating at the equipment that meets or exceeds the available short circuit current at the switchboard or panelboard where the equipment circuit originates.
   2. Provide calculations, based on the available short circuit current at the switchboard or panelboard where the equipment circuit originates, that document

the actual short circuit current available at the equipment. The SCCR rating of the equipment shall meet or exceed this calculated value.

2.3 MATERIALS

A. Unless otherwise specified, all materials and equipment shall be new, unused and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production.

2.4 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

A. Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.5 QUANTITY OF SPECIFIED ITEMS REQUIRED

A. Wherever in these specifications an article, device or piece of equipment is referred to in the singular number; such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.6 SLEEVES

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

PART 3 EXECUTION

3.1 GENERAL

A. Fabrication, erection, and installation of the complete electrical system shall be done by qualified personnel experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the project.

B. Check areas and surfaces where electrical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.

C. Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the electrical work.

D. Install equipment and systems in accordance with manufacturer's instructions, requirements, or recommendations.

E. Comply with NECA 1.

F. Unless otherwise noted, measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

G. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

H. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

I. Right of Way: Give to raceways and piping systems installed at a required slope.

J. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

3.2 DELIVERY AND STORAGE OF MATERIALS

A. Make provisions for the delivery and safe storage of materials.

B. Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.

C. Adequately protect supplies and equipment during cold weather.

D. Protect items subject to cold weather damage by covering, insulating, or storing in a heated space.

3.3 COOPERATION WITH OTHER CONTRACTORS

A. Perform the electrical work in conformance with the construction called for by other trades and afford other contractors reasonable opportunity for the execution of their work.

B. Properly connect and coordinate the electrical work with the work of other contractors at such time and in such a manner as not to delay or interfere with their work.

C. Examine the contract documents for the General, Mechanical, and Electrical work and the work of other trades. Coordinate work accordingly.

D. Promptly report to the Engineer any delay or difficulties encountered in the installation of the electrical work which might prevent prompt and proper installation of work required from other trades.

3.4 COORDINATION OF WORK

A. Plan work so it proceeds with a minimum of interference with other trades.

B. Inform the General Contractor of all openings required in the building construction for the installation of the electrical work.

C. Cooperate with other contractors in furnishing material and information, in proper sequence, for the correct location of sleeves, inserts, foundations, wiring, etc.

D. Make provisions for special frames, openings, and sleeves as required.

E. The Electrical Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.5 LAYING OUT WORK

A. Carefully lay out work in advance of installation using data and measurements from the site, the appropriate architectural and structural drawings, and shop drawings.

B. Confirm code required clearances.

C. Do not infringe upon space required for operation, maintenance, or clearance for items installed by other contractors.

D. Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.

E. If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Engineer prior to installation and request clarification.

F. Failure to properly coordinate and lay out work will require correction by the Contractor at the Contractor’s expense

3.6 DATA AND MEASUREMENTS

A. Mechanical and Electrical drawings are diagrammatic or schematic. Do not scale drawings.

B. The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.

C. Obtain exact locations, measurements, levels, etc., at the site and adapt their work to actual conditions.

D. Examine the General Construction, Mechanical, Electrical, and other applicable drawings and the Specifications.

E. Utilize only Architectural drawings, Structural drawings, and site measurements in calculations.

F. Layout and coordinate work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.

G. Locate outlets and devices mounted on finished surfaces with regard to paneling, furring, trim, etc.

H. Install outlets and devices with vertical edges of plates plumb.

I. Install boxes or plaster rings such that the front edge extends to the finished surface of the wall, ceiling or floor without projecting beyond the surface.

J. Install receptacles, switches, etc., on wood trim, cases, or other fixtures symmetrically and, where necessary, install with the long dimension of the plate horizontal.

K. Coordinate locations of outlets and devices with other contractors so as not to destroy the aesthetic effect of the surface in which the outlets and devices are mounted. Coordinate the locations of electrical items with work furnished by other trades to avoid interference.

L. Heights of outlets are measured from finished floor to centerline of device.

M. Adjust heights as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.

N. Mounting heights shall be in compliance with ADA requirements.

O. Install outlets at the heights indicated below unless otherwise noted.
1. Wall switches: 46 inches.
2. Receptacle outlets (general): 18 inches.
3. Pushbuttons: 46 inches.
4. Fire alarm station: 46 inches.
5. Fire alarm visual signals and audible/visual signals, wall-mounted: 80 inches to the bottom of the lens unless local code or ADA requirement mandates a lower mounting height.
6. Fire alarm audible signals, wall-mounted: Match height of audible/visual signals.

P. The mounting heights of disconnect switches, circuit breakers, motor controllers, pushbutton stations and other similar devices and equipment may vary depending upon location and whether individually or group mounted.

Q. For convenience and safety, mount equipment with the center of operating levers, handles or buttons no more than 72 inches above the finished floor.

R. Locate individual devices or pieces of equipment, unless otherwise specified, so the operating handle, lever or button is located approximately 5 feet above finished floor. Coordinate heights of electrical items with work furnished by other trades to avoid interferences.

S. Improperly located devices or outlets shall be relocated by the Contractor at the Contractor’s expense including necessary patching.

3.7 PROTECTION OF APPARATUS

A. Take necessary precautions to properly protect apparatus, fixtures, appliances, material, equipment, and installations from damage.

B. Failure to provide such protection to the satisfaction of the Engineer shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.8 SLEEVE INSTALLATION

A. Coordinate sleeve selection and application with selection and application of firestopping.

B. Concrete Slabs and Walls: Install sleeves during erection of slabs and walls. Space sleeves a minimum of three sleeve diameters on center, unless otherwise noted. Sleeves are not required for core-drilled penetrations.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Sleeves through walls: Install flush with both surfaces of wall.

E. Sleeves through floors: Extend 2 inches above finished floor.

F. Sleeves through roofs: Seal with flexible boot-type flashing units applied in coordination with roofing work

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceways or cable unless sleeve seal is to be installed.

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

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.

J. Underground, Exterior-Wall Penetrations: Size sleeves to allow for appropriate clear space between raceway and sleeve for sleeve seals.

3.9 FIRESTOPPING

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

3.10 WORK IN EXISTING BUILDINGS

A. Execute work in the existing building, indicated on the drawings or specified herein, with a minimum amount of interference with the normal activities of the occupants of the building.

B. Schedule work in advance with the Owner and proceed only with the Owner’s written approval.

C. Utilities:
   1. Do not interrupt utilities without the Owner’s prior written approval regarding the time and duration of such interruptions.
   2. Do not disconnect utilities to existing facilities until new or temporary facilities are installed except for short periods of interruption which are necessary for the performance of the new work and which are approved by the Owner.

3. Storm water may be temporarily diverted to surface drainage provided such drainage is arranged to prevent flooding of structures, basements and excavations for construction.

D. Fire Alarm System:
1. As a minimum, maintain the existing degree of protection for all areas throughout construction.
2. Coordinate required outages with the Owner and the Fire Marshal.
3. After any additions or modifications to the fire alarm system, a re-acceptance test shall be performed by a licensed party in accordance with NFPA 72.

E. Welding:
1. Notify the Owner before starting welding or cutting.
2. Fire extinguishers shall be immediately accessible when welding or cutting with an open flame or arc.
3. Stop operations involving welding or cutting with an open flame or arc not less than one hour before leaving the premises.

F. Noisy Operations:
1. Schedule noisy operations, such as those involving use of air hammers, etc., in demolition or cutting of openings, with the Owner.

G. Occupancy:
1. The Owner will continue to occupy the building and carry on normal activity.
2. Protect the occupied areas from dust, smoke, etc., by a method reviewed by the Engineer.

H. Owner's Right to Direct Work: The Owner shall have the right to direct the places of beginning work, its prosecution, and the manner in which all work under this contract is to be conducted, insofar as may be necessary to secure the safe and proper progress and quality of the work.

I. Existing Conduits or Electrical Equipment:
1. Remove or relocate, as required, or as directed by the Engineer, existing conduit or electrical equipment which would interfere with the proper installation of new work.
2. Modify existing work in conformance with these specifications.
3. Use the same materials as for new work unless otherwise specified.

3.11 DEMOLITION AND REMODEL

A. Protect existing electrical equipment and installations indicated to remain.

B. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

C. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

D. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.

E. Remove demolished material from Project site.

F. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

G. Remove existing lights, receptacles, switches, etc., indicated on plans or which are not indicated but must be removed to accommodate demolition or new remodeling.

H. Where existing walls are indicated to be removed, disconnect power to electrical devices and associated appurtenances relating to the walls.

I. Maintain circuit continuity up and down stream from removed outlets.

J. Extend circuiting to up and downstream devices and reconnect as required.

K. Where existing site lighting fixtures are removed, verify the routing of existing circuits. Maintain circuit continuity between existing fixtures which remain.

L. In areas which are remodeled, replace existing wire with new wire. No existing wire is permitted to remain unless noted.

M. Existing concealed conduit and boxes may be reused.

N. Verify existing conditions in field prior to bid date.

3.12 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations.

B. Perform cutting by skilled mechanics of trades involved.

C. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces.

D. Install new fireproofing where existing firestopping has been disturbed.

E. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.13 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work. Repair as necessary.

3.14 CLEANING AND PROTECTION

A. Remove burrs, dirt, paint spots, and construction debris from electrical items.

B. Protect electrical items so that finishes are without damage or deterioration at time of Substantial Completion.

C. All cables and wiring shall be protected from paint. This includes but is not limited to power conductors and feeders, lighting control wiring, and fire alarm cabling. Painted cables shall be replaced in their entirety.

3.15 TEMPORARY POWER AND LIGHTING

A. Provide temporary power and lighting throughout the construction period for the use by all trades, Contractors and Sub-Contractors.

B. Temporary facilities shall be installed in compliance with applicable codes and in compliance with OSHA requirements.

C. Cost of temporary power used during construction, including the cost of setting and removing temporary service, shall be paid by the Contractor.

D. Where existing building electrical system is used to provide temporary power and lighting, energy costs shall be paid by the Owner.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Single conductor building wire.

B. Power and control tray cable.

C. Wiring connectors.

D. Electrical tape.

E. Heat shrink tubing.

F. Oxide inhibiting compound.

G. Cable ties.

1.2 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire.

B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.

D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation.

E. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

F. NECA 1 - Standard for Good Workmanship in Electrical Construction.

G. NECA 104 - Standard for Installing Aluminum Building Wire and Cable.

H. NECA 120 - Standard for Installing Armored Cable (AC) and Type Metal-Clad (MC) Cable.

I. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.

J. NFPA 70 - National Electrical Code.

K. UL 44 - Thermoset-Insulated Wires and Cables.

L. UL 83 - Thermoplastic-Insulated Wires and Cables.

M. UL 486A-486B - Wire Connectors.

N. UL 486C - Splicing Wire Connectors.

O. UL 486D - Sealed Wire Connector Systems.

P. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

Q. UL 1277 - Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

A. Provide products that comply with requirements of NFPA 70.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.

D. Comply with NEMA WC 70.

E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.

F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.

G. Conductors and Cables Installed in Cable Tray: Listed and labeled as suitable for cable tray use.

H. Conductor Material:
1. Provide copper conductors except where aluminum conductors are specifically indicated. Substitution of aluminum conductors for copper is not permitted. Conductor sizes indicated are based on copper unless specifically indicated as aluminum. Conductors designated with the abbreviation "AL" indicate aluminum.
2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
3. Tinned Copper Conductors: Comply with ASTM B33.
4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.

I. Minimum Conductor Size:
1. Branch Circuits: 12 AWG.
2. Control Circuits: 14 AWG.

J. Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
2. Color Coding Method: Integrally colored insulation.
a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
3. Color Code:
a. 480Y/277 V, 3 Phase, 4 Wire System:
1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.
4) Neutral/Grounded: Gray.
b. 208Y/120 V, 3 Phase, 4 Wire System:
1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.
4) Neutral/Grounded: White.
c. Equipment Ground, All Systems: Green.
d. For control circuits, comply with manufacturer's recommended color code.

2.2 SINGLE CONDUCTOR BUILDING WIRE

A. Description: Single conductor insulated wire.

B. Conductor Stranding:
1. Feeders and Branch Circuits:
a. Size 10 AWG and Smaller: Solid.

b. Size 8 AWG and Larger: Stranded.

C. Insulation Voltage Rating: 600 V.

D. Insulation:
1. Copper Building Wire: Type THHN/THWN, THHN/THWN-2, or XHHW-2, except as indicated below.
a. Installed Underground: Type XHHW-2 or THHN/THWN-2.

2.3 POWER AND CONTROL TRAY CABLE

A. Description: NFPA 70, Type TC cable listed and labeled as complying with UL 1277.

B. Conductor Stranding: Stranded.

C. Insulation Voltage Rating: 600 V.

D. Insulation: Type XHHW or XHHW-2.

E. Jacket: PVC or Chlorinated Polyethylene (CPE).

2.4 WIRING CONNECTORS

A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

B. Wiring Connectors for Splices and Taps:
1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.

C. Wiring Connectors for Terminations:
1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
2. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.

D. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.

E. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

F. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.

G. Mechanical Connectors: Provide bolted type or set-screw type.

H. Compression Connectors: Provide circumferential type or hex type crimp configuration.

2.5 ACCESSORIES

A. Electrical Tape:
1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.

B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.

C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.

D. Cable Ties: Material and tensile strength rating suitable for application.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that work likely to damage wire and cable has been completed.

C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.

D. Verify that field measurements are as indicated.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.3 INSTALLATION

A. Circuiting Requirements:
1. When circuit destination is indicated without specific routing, determine exact routing required.
2. Install service and feeder conductors unspliced unless otherwise indicated.
3. Arrange branch circuiting to minimize splices.

4. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
5. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
6. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is permitted, under the following conditions:
    a. Provide no more than 6 #12 AWG current-carrying conductors in 1/2 inch conduit; 9 #12 AWG current-carrying conductors in 3/4 inch conduit.
    b. Provide no more than 6 #10 AWG current-carrying conductors in 3/4 inch conduit; 9 #10 AWG current-carrying conductors in 1 inch conduit.
    c. Provide no more than 4 #8 AWG current-carrying conductors in 3/4 inch conduit; 6 #8 AWG current-carrying conductors in 1 inch conduit; 9 #8 AWG current-carrying conductors in 1-1/4 inch conduit.
7. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.

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

C. Perform work in accordance with NECA 1 (general workmanship).

D. Install aluminum conductors in accordance with NECA 104.

E. Install metal-clad cable (Type MC) in accordance with NECA 120.

F. Installation in Raceway:
1. Pull all conductors and cables together into raceway at same time.
2. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
3. Use suitable wire pulling lubricant where necessary, except as below:
    a. Do not use when lubricant is not recommended by the conductor manufacturer.

G. Exposed Cable Installation (only where specifically permitted):
1. Route cables parallel or perpendicular to building structural members and surfaces.
2. Protect cables from physical damage.

H. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.

I. Terminate cables using suitable fittings.
1. Metal-Clad Cable (Type MC):
    a. Use listed fittings.
    b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.

J. Install conductors with a minimum of 6 inches of slack at each outlet.

K. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

L. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.

M. Make wiring connections using specified wiring connectors.
   1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies.
   2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
   3. Do not remove conductor strands to facilitate insertion into connector.
   4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
   5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
   6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
   7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

N. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
   1. Dry Locations: Use insulating covers specifically designed for the connectors or heat shrink tubing.
   2. Damp Locations: Use insulating covers specifically designed for the connectors or heat shrink tubing.
      a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
   3. Wet Locations: Use heat shrink tubing.

O. Insulate ends of spare conductors using vinyl insulating electrical tape.

P. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.

Q. Identify conductors and cables in accordance with Section 26 05 53.

R. Install firestopping to preserve fire resistance rating of partitions and other elements.

S. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Grounding and bonding requirements.

B. Conductors for grounding and bonding.

C. Connectors for grounding and bonding.

1.2 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction.

B. NFPA 70 - National Electrical Code.

C. UL 467 - Grounding and Bonding Equipment.

D. TIA/EIA-607 - Commercial Building Grounding and Bonding Requirements for Telecommunications

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 DEFINITIONS

A. ACEG: Alternating Current Equipment Ground

B. BCT: Bonding Conductor for Telecommunications (formerly Telecommunications Bonding Conductor)

C. BBC: Backbone Bonding Conductor (formerly Grounding Equalizer)

D. PBB: Primary Bonding Busbar (formerly Telecommunications Main Grounding Busbar)

E. SBB: Secondary Bonding Busbar (formerly Telecommunications Grounding Busbar)

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Comply with TIA/EIA-607 for telecommunications grounding.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING REQUIREMENTS

A. Do not use products for applications other than as permitted by NFPA 70 and product listing.

B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.

C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

D. Bonding and Equipment Grounding:
   1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
   2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
   3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
   4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
   5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
   6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
   7. Provide bonding for metal building frame.

2.2 GROUNDING AND BONDING COMPONENTS

A. General Requirements:
   1. Provide products listed, classified, and labeled as suitable for the purpose intended.
   2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 05 26:
   1. Use insulated copper conductors unless otherwise indicated.
      a. Exceptions:
         1) Use bare tinned copper conductors where installed underground in direct contact with earth.

2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections, high-pressure compression conections, or high-pressure compression conections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use compression connectors for accessible connections. For #6 AWG and smaller, use one-hole lugs. For #4 AWG and larger, use two-hole lugs.
a. Exceptions:
1) Use exothermic welded connections or high-pressure compression connections for connections to metal building frame.
4. Manufacturers - High-Pressure Compression Connectors:
a. Burndy: www.burndy.com; Hyground System
b. Thomas & Betts: www.tnb.com.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.

B. Verify that field measurements are as indicated.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

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

B. Perform work in accordance with NECA 1 (general workmanship).

C. Install each bonding conductor in a direct route, and parallel or perpendicular to building structure or surfaces, without interfering with other systems or equipment.

D. Install exterior grounding electrode conductors with a minimum bending radius of 12 inches.

E. Install interior grounding conductors with a minimum bending radius of 8 inches.

F. Install grounding conductors in EMT conduit unless otherwise indicated. Bond each end of the conduit to the grounding conductor using an appropriate grounding bushing.

G. Make grounding and bonding connections using specified connectors.

1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

H. Identify grounding and bonding system components in accordance with Section 26 05 53.
1. Clean each surface prior to attachment of label.
2. Follow manufacturer's recommendations for affixing labels.

3.3 FIELD QUALITY CONTROL

A. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.

B. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.2 REFERENCE STANDARDS

A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

D. MFMA-4 - Metal Framing Standards Publication.

E. NECA 1 - Standard for Good Workmanship in Electrical Construction.

F. NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
   2. Coordinate work to provide additional framing and materials required for installation.
   3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
   4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
   5. Notify Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
   1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:
1. Comply with the following. Where requirements differ, comply with most stringent.
a. NFPA 70.
b. Requirements of authorities having jurisdiction.
2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
6. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
7. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Conduit and Cable Supports: Straps and clamps suitable for conduit or cable to be supported.
1. Conduit Straps: One-hole or two-hole type; steel.
2. Conduit Clamps: Bolted type unless otherwise indicated.

C. Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.

D. Metal Channel/Strut Framing Systems:
1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
2. Comply with MFMA-4.
3. Channel Material:
a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.

E. Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.

F. Anchors and Fasteners:
1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.

2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts, expansion anchors, or expansion anchors.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Sheet Metal: Use sheet metal screws.
8. Wood: Use wood screws.

G. Cable Supports for Vertical Conduit: Factory-fabricated body with insulated wedging plug, appropriately sized for conductors being supported.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

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

B. Install hangers and supports in accordance with NECA 1.

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.

F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

G. Equipment Support and Attachment:
1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
2. Use metal channel (strut) secured to studs to support equipment surface-mounted on walls when wall strength is not sufficient to resist pull-out.
3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3-1/2 inch high concrete pad.
5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
6. Install surface-mounted cabinets and panelboards with minimum of four anchors.

H. Secure fasteners in accordance with manufacturer's recommended torque settings.

I. Remove temporary supports.

J. Identify independent electrical component support wires above accessible ceilings, where permitted, with color distinguishable from ceiling support wires in accordance with NFPA 70.

END OF SECTION

SECTION 26 05 33.13

CONDUIT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Galvanized steel rigid metal conduit (RMC).

B. Flexible metal conduit (FMC).

C. Liquidtight flexible metal conduit (LFMC).

D. Galvanized steel electrical metallic tubing (EMT).

E. Accessories.

1.2 REFERENCE STANDARDS

A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC).

B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S).

C. NECA 1 - Standard for Good Workmanship in Electrical Construction.

D. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT).

E. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.

F. NFPA 70 - National Electrical Code.

G. UL 1 - Flexible Metal Conduit.

H. UL 6 - Electrical Rigid Metal Conduit-Steel.

I. UL 360 - Liquid-Tight Flexible Metal Conduit.

J. UL 514B - Conduit, Tubing, and Cable Fittings.

K. UL 797 - Electrical Metallic Tubing-Steel.

L. UL 2419 - Outline of Investigation for Electrically Conductive Corrosion Resistant Compounds.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate minimum sizes of conduits with actual type and quantity of conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment, and other potential conflicts.
3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
5. Notify Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
1. Do not begin installation of conductors and cables until installation of conduit between termination points is complete.

1.4 QUALITY ASSURANCE

1.5 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, manufacturer's instructions, and product listing.

B. Outdoor Locations Above Grade: Use rigid steel conduit.

C. Dry Locations:
1. Concealed: Use electrical metallic tubing.
2. Exposed: Use rigid steel conduit.

D. Connection to Motors: Use liquid-tight flexible metal conduit, except use flexible metal conduit in air plenums.

E. Connection to Vibrating Equipment (including transformers):
1. Indoors: Use flexible metal conduit.
2. Outdoors: Use liquid-tight flexible metal conduit.

2.2 CONDUIT - GENERAL REQUIREMENTS

A. Comply with NFPA 70.

B. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling mandrel through them.

C. Provide conduit, fittings, supports, and accessories required for complete raceway system.

D. Provide products listed, classified, and labeled as suitable for purpose intended.

E. Minimum Conduit Size, Unless Otherwise Indicated:
   1. Branch Circuits: 1/2-inch trade size.

F. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.3 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.

B. Fittings:
   1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.
   2. Material: Use steel or malleable iron.
   3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.4 FLEXIBLE METAL CONDUIT (FMC)

A. Description: NFPA 70, Type FMC standard-wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems.

B. Fittings:
   1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   2. Material: Use steel, malleable iron, or die cast zinc.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360; rated for use with conductors rated 75 degrees C.

B. Fittings:
   1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   2. Material: Use steel, malleable iron, or die cast zinc.

2.6 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

A. Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

B. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel, malleable iron, or die cast zinc.
3. Connectors and Couplings: Use compression/gland or set-screw type.
    a. Do not use indenter type connectors and couplings.
4. Damp or Wet Locations, Where Permitted: Use fittings listed for use in wet locations.

2.7 ACCESSORIES

A. Conduit Joint Compound: Corrosion-resistant, electrically conductive compound listed as complying with UL 2419; suitable for use with conduit to be installed.

B. Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 200 lbf.

C. Foam Conduit Sealant:
1. Removable, two-part, closed-cell foam, specifically designed for sealing conduit openings against water, moisture, gases, and dust.
2. Suitable for use with conductors/cables and associated insulation/jackets to be installed.
3. Rated to hold minimum of 10 ft water head pressure.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive conduits.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

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

B. Install conduit in accordance with NECA 1.

C. Galvanized Steel Rigid Metal Conduit (RMC): Install in accordance with NECA 101.

D. Conduit Routing:
1. Unless dimensioned, conduit routing indicated is diagrammatic.
2. When conduit destination is indicated without specific routing, determine exact routing required.
3. Conceal conduits unless specifically indicated to be exposed.
4. Conduits in the following areas may be exposed, unless otherwise indicated:
    a. Electrical rooms.
    b. Mechanical equipment rooms.
5. Unless otherwise approved, do not route exposed conduits:
    a. Across floors.

b. Across roofs.
c. Across top of parapet walls.
d. Across building exterior surfaces.

6. Arrange conduit to maintain adequate headroom, clearances, and access.
7. Arrange conduit to provide no more than equivalent of four 90-degree bends between pull points.
8. Exterior Branch Circuits: Route conduits adjacent to curbs. Push or directional bore conduits beneath paved areas; otherwise, sawcut and remove pavement. Replace removed pavement to match existing.
9. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
10. Maintain minimum clearance of 12 inches between conduits and hot surfaces.
11. Group parallel conduits in same area on common rack.

E. Conduit Support:

1. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods approved by authorities having jurisdiction; see Section 26 05 29.
   a. Support PVC conduit within 3 feet of termination points and at intervals not exceeding those listed below in accordance with NFPA 70 Table 352.30.
      1) 1/2" to 1" trade size = 3 feet spacing between supports.
      2) 1-1/4" to 2" trade size = 5 feet spacing between supports.
      3) 2-1/2" to 3" trade size = 6 feet spacing between supports.
      4) 3-1/2" to 5" trade size = 7 feet spacing between supports.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
4. Use of spring steel conduit clips for support of conduits is permitted only as follows:
   a. Support of electrical metallic tubing (EMT)1-1/2 inch trade size concealed above accessible ceilings and within hollow stud walls.
5. Use of wire for support of conduits is permitted only as follows:
   a. For suspending conduits supported by spring steel conduit clips, where specifically indicated or permitted.

F. Connections and Terminations:

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.

5. Provide insulated bushings on box connectors 1-inch and larger, on conduits stubbed above an accessible ceiling, and on conduits used for telecommunications pathways.
6. Secure joints and connections to provide mechanical strength and electrical continuity.

G. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
4. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty.
5. Install firestopping to preserve fire resistance rating of partitions and other elements.

H. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
2. Where conduits are subject to earth movement by settlement or frost.

I. Conduit Sealing:
1. Use foam conduit sealant to prevent entry of moisture and gases. This includes, but is not limited to:
   a. Where conduits enter building from outside.
   b. Where service conduits enter building from underground distribution system.
   c. Where conduits enter building from underground.
   d. Where conduits may transport moisture to contact live parts.
2. Where conduits cross barriers between areas of potential substantial temperature differential, use foam conduit sealant, junction box, or type C condulet at accessible point near penetration to prevent condensation. This includes, but is not limited to:
   a. Where conduits pass from outdoors into conditioned interior spaces.
   b. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.

J. Provide pull string in each empty conduit and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.

K. Provide grounding and bonding; see Section 26 05 26.

L. Identify conduits; see Section 26 05 53.

3.3 FIELD QUALITY CONTROL

A. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

B. Correct deficiencies and replace damaged or defective conduits.

3.4 CLEANING

A. Clean interior of conduits to remove moisture and foreign matter.

3.5 PROTECTION

A. Immediately after installation of conduit, use suitable caps to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

SECTION 26 05 33.16

BOXES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.

B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.

C. Poke thru devices.

1.2 REFERENCE STANDARDS

A. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

B. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.

C. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

D. NFPA 70 - National Electrical Code.

E. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

F. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.

G. UL 508A - Industrial Control Panels.

H. UL 514A - Metallic Outlet Boxes.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
   4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
   5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
   6. Coordinate the work with other trades to preserve insulation integrity.

7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
8. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 BOXES

A. General Requirements:
1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
3. Provide products listed, classified, and labeled as suitable for the purpose intended.
4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
3. Use suitable concrete type boxes where flush-mounted in concrete.
4. Use suitable masonry type boxes where flush-mounted in masonry walls.
5. Use raised covers suitable for the type of wall construction and device configuration where required.
6. Do not use "through-wall" boxes designed for access from both sides of wall.
7. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
8. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
9. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
10. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
11. Minimum Box Size, Unless Otherwise Indicated:
a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.

b. Communications Systems Outlets: 4 inch square by 2-1/8 inch deep trade size.
c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.

12. Wall Plates: Comply with Section 26 27 26.

C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:

1. Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
2. NEMA EN 10250 Environment Type, Unless Otherwise Indicated:
   a. Indoor Clean, Dry Locations: Type 1, painted steel.
   b. Outdoor Locations: Type 3R, painted steel.
3. Junction and Pull Boxes Larger Than 100 cubic inches:
   a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
   b. Include cable supports if any dimension of the box is greater than 48 inches.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive boxes.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Verify locations of floor boxes prior to rough-in.

3.2 INSTALLATION

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

B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.

E. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.

F. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.

G. Box Locations:

1. Locate boxes to be accessible. Provide access panels as required where approved by the Architect.
2. Unless dimensioned, box locations indicated are approximate.
3. Locate boxes as required for devices installed under other sections or by others.
4. Locate boxes so that wall plates do not span different building finishes.
5. Locate boxes so that wall plates do not cross masonry joints.
6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.
9. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
    a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
10. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 05 33.13.
11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
    a. Concealed above accessible suspended ceilings.
    b. Within joists in unfinished areas with no ceiling.
    c. Electrical rooms.
    d. Mechanical equipment rooms.

H. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
4. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.

I. Install boxes plumb and level.

J. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.

2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.

K. Install boxes as required to preserve insulation integrity.

L. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

M. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.

N. Close unused box openings.

O. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.

P. Provide grounding and bonding in accordance with Section 26 05 26.

Q. Identify boxes in accordance with Section 26 05 53.

R. Orient boxes to accommodate wiring devices oriented as specified in Section 26 27 26.

S. Orient each box located above an accessible ceiling so the box opening faces down or to one side.

T. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

U. Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.

V. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.

3.3 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical identification requirements.

B. Identification nameplates and labels.

C. Identification for conductors.

D. Warning signs and labels.

1.2 REFERENCE STANDARDS

A. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs.

B. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels.

C. NFPA 70 - National Electrical Code.

D. NFPA 70E - Standard for Electrical Safety in the Workplace.

1.3 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 IDENTIFICATION REQUIREMENTS

A. Identification for Equipment:
   1. Use identification nameplate to identify electrical equipment.
      a. Panelboards:
         1) Identify panelboard name.
         2) Identify power source and circuit number. Include location when not within sight of equipment.
         3) Use typewritten circuit directory to identify load(s) served for panelboards with a door.
         4) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device.
      b. Enclosed switches, circuit breakers, and motor controllers:
         1) Identify power source and circuit number. Include location when not within sight of equipment.
         2) Identify load(s) served.
   2. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".

3. Available Fault Current Documentation: Use identification nameplate to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
4. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized.
    a. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.

B. Identification for Conductors and Cables:
1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19.
2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

C. Identification for Raceways:
1. Use underground warning tape to identify underground raceways.

D. Identification for Boxes:
1. Use color-coded box covers to identify specified systems.
    a. Color-Coded Box Covers: Field-painted with two coats of enamel paint per the color code below:
        1) Fire Alarm System: Red.
    b. For exposed boxes in public areas, do not color code.
2. Use handwritten text using indelible marker to identify circuits enclosed.
    a. For exposed boxes in public areas, provide identification on inside face of cover.

E. Identification for Devices:
1. Wiring Device and Wallplate Finishes: Comply with Section 26 27 26.

2.2 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:
1. Materials:
    a. Indoor Clean, Dry Locations: Use plastic nameplates.
2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
    a. Color: White text on black background.

B. Identification Labels:

1. Manufacturers:
    a. Brady Corporation: www.bradyid.com/#sle.
    b. Brother International Corporation: www.brother-usa.com/#sle.
    c. Panduit Corp: www.panduit.com/#sle.
2. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
    a. Use only for indoor locations.
3. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
4. Color: Black text on clear background. Provide black text on white background when applying to a dark surface.

C. Format for Equipment Identification:
1. Minimum Size:
    a. Plastic Nameplates: 1 inch by 2.5 inches.
    b. Identification Labels: 0.5 inch by 2.5 inches.
2. Minimum Size: 1 inch by 2.5 inches.
3. Legend:
    a. Equipment designation or other approved description.
4. Text: All capitalized unless otherwise indicated.
5. Minimum Text Height:
    a. Equipment Designation: 3/8 inch.

2.3 WARNING SIGNS AND LABELS

A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.

B. Warning Labels:
1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.2 INSTALLATION

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

B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
1. Surface-Mounted Equipment: Enclosure front.
2. Flush-Mounted Equipment: inside of equipment door when installed in a finished location.

3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
4. Elevated Equipment: Legible from the floor or working platform.
5. Boxes: Outside face of cover.
6. Devices: Outside face of cover.

C. Install identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws or self-adhesive backing and to interior surfaces using self-adhesive backing.

E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Mark all handwritten text, where permitted, to be neat and legible.

3.3 FIELD QUALITY CONTROL

A. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

SECTION 26 05 83

WIRING CONNECTIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical connections to equipment.

1.2 REFERENCE STANDARDS

A. NEMA WD 6 - Wiring Devices - Dimensional Specifications.

B. NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
2. Determine connection locations and requirements.

B. Sequencing:
1. Install rough-in of electrical connections before installation of equipment is required.
2. Make electrical connections before required start-up of equipment.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.1 MATERIALS
1. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
2. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

C. Provide receptacle outlet to accommodate connection with attachment plug.

D. Provide cord and cap where field-supplied attachment plug is required.

E. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

F. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

G. Provide final power and control connections for equipment furnished under other Divisions of this specification and for Owner-furnished equipment. Where not specified in mechanical sections of this specification, connect motor controls and associated mechanical equipment as required for a complete and functional control system.

H. Provide interlocks and wiring to and between controls for Owner-furnished equipment, air handling units, condensing units, and energy management system.

I. Verify control wiring requirements with manufacturer certified shop drawings for each piece of equipment or control system and install accordingly. Install control wiring in conduit.

3.3 EQUIPMENT REQUIREMENTS

A. Electric Water Coolers:
   1. Locate receptacle for each electric water cooler so that cord and plug are concealed inside or behind cooler.

B. Temperature Control / Energy Management System Panels:
   1. Provide a dedicated power circuit from the nearest 120 V general purpose panel to each temperature control, energy management system, or data gathering panel.
   2. Coordinate panel quantities and locations with Installing Contractor.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Lighting and appliance panelboards.

B. Overcurrent protective devices for panelboards.

C. Coordination panels.

1.2 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction.

B. NECA 407 - Standard for Installing and Maintaining Panelboards.

C. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

D. NEMA PB 1 - Panelboards.

E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

F. NFPA 70 - National Electrical Code.

G. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

H. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.

I. UL 67 - Panelboards.

J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.

K. UL 943 - Ground-Fault Circuit-Interrupters.

L. UL 1699 - Arc-Fault Circuit-Interrupters.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.

3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.

B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.

C. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.

D. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Panelboard Keys: six of each different key.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. ABB/GE: www.electrification.us.abb.com.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier, where possible.

2.2 PANELBOARDS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature:
      a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
      b. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.

C. Short Circuit Current Rating:
   1. Provide panelboards with listed short circuit current rating as indicated on the drawings. Where the available fault current is indicated, provide panelboards with listed short circuit current rating not less than the available fault current.
   2. Listed series ratings are acceptable only where specifically indicated.
   3. Label equipment utilizing series ratings as required by NFPA 70.

D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation. Do not reduce panelboard pole quantity or mounting spaces indicated on drawings by installation of branch-mounted main device, where used. Provide additional poles or spaces as required.

E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
   1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
   2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.

G. Conductor Terminations: Suitable for use with the conductors to be installed.

H. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:

a. Indoor Clean, Dry Locations: Type 1.

2. Boxes: Galvanized steel unless otherwise indicated.
   a. Provide wiring gutters sized to accommodate the conductors to be installed.
3. Fronts:
   a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
   b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
   c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
4. Lockable Doors: All locks keyed alike unless otherwise indicated.

I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list and label panelboards as a complete assembly including surge protective device. Unless otherwise indicated, do not reduce panelboard pole quantity or mounting spaces indicated on drawings by installation of surge protective device. Provide additional poles or spaces as required.

K. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.

2.3 LIGHTING AND APPLIANCE PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations:
1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
2. Main and Neutral Lug Type: Mechanical.

C. Bussing:
1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
2. Phase and Neutral Bus Material: Aluminum or copper.
3. Ground Bus Material: Aluminum or copper.

D. Circuit Breakers: Thermal magnetic bolt-on type.

E. Enclosures:
1. Provide surface-mounted or flush-mounted enclosures as indicated.
2. Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
3. Provide clear plastic circuit directory holder mounted on inside of door.
4. Minimum dimensions: 5-1/2 inches deep, 20 inches wide.

2.4 OVERCURRENT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers:
1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
2. Interrupting Capacity:
a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
2) 14,000 rms symmetrical amperes at 480 VAC.
b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
3. Conductor Terminations:
a. Provide mechanical lugs unless otherwise indicated.
b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
6. Provide the following circuit breaker types where indicated:
a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
b. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
7. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting.
8. Provide listed high intensity discharge lighting rated circuit breakers with HID marking for all branch circuits serving HID lighting.
9. Do not use tandem circuit breakers.
10. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
11. Provide the following features and accessories where indicated or where required to complete installation:
a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive panelboards.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship).

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

C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

E. Provide required support and attachment in accordance with Section 26 05 29.

F. Install panelboards plumb.

G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.

H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.

I. Provide minimum of five spare 3/4 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling.

J. Provide grounding and bonding in accordance with Section 26 05 26.

K. Install all field-installed branch devices, components, and accessories.

L. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.

M. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

N. Provide filler plates to cover unused spaces in panelboards.

O. Identify panelboards in accordance with Section 26 05 53.

P. If the overcurrent protection for a panelboard feeder is less than the nameplate rating of the panelboard, provide a plastic nameplate indicating the ampacity of the feeder circuit. Attach nameplate to the inside of the panelboard so it is visible when the panelboard door is opened.

Q. Connections:
   1. Connect phase conductors A, B, C left to right as viewed from the front of the panel unless bus bars are factory labeled otherwise.
   2. Connect each branch circuit served by a lighting and appliance branch circuit panelboard to a 20A 1-pole breaker unless otherwise indicated.

3. Circuit numbering indicated for lighting and appliance branch circuit panelboards is based on pole position within the panelboard. For multipole breakers, the circuit number corresponds to the first pole position occupied by the breaker.
4. Circuit number indicated for distribution panelboards is based on consecutive numbering.

3.3 FIELD QUALITY CONTROL

A. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.

B. Test GFCI circuit breakers to verify proper operation.

C. Test AFCI circuit breakers to verify proper operation.

D. Test shunt trips to verify proper operation.

E. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of panelboard fronts.

3.5 CLEANING

A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Receptacles.

B. Device plates and box covers.

1.2 REFERENCE STANDARDS

A. NEMA WD 1 - General Color Requirements for Wiring Devices.

B. NEMA WD 6 - Wiring Devices - Dimensional Specifications.

C. NFPA 70 - National Electrical Code.

D. UL 498 - Attachment Plugs and Receptacles.

E. UL 514D - Cover Plates for Flush-Mounted Wiring Devices.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
5. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

B. Sequencing:
1. Do not install wiring devices until final surface finishes and painting are complete.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.6 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.1 WIRING DEVICES - GENERAL REQUIREMENTS

A. Provide wiring devices suitable for intended use with ratings adequate for load served.

2.2 MANUFACTURERS

A. Cooper Wiring Devices: www.cooperwiringdevices.com.

B. Hubbell Incorporated: www.hubbell-wiring.com.

C. Leviton Manufacturing Company, Inc: www.leviton.com.

D. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us

E. Source Limitations: Where possible, provide products for each type of wiring device produced by a single manufacturer and obtained from a single supplier.

2.3 WIRING DEVICE FINISHES

A. Device Color: Gray unless otherwise indicated or required by code; brown in dark brick, wood paneled or dark-finished walls.

2.4 RECEPTACLES

A. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498; types as indicated on the drawings.
   1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
   2. NEMA configurations specified are according to NEMA WD 6.

B. Acceptable products are listed below for specific device types.

C. Straight Blade Receptacles: 20A, 125V.

Description	Cooper	Hubbell	Leviton	P & S
Simplex	1877	HBL5361	5891	5361
Duplex	BR20	BR20	5362	CRB5362
Duplex tamper resistant	TRBR20	BR20TR	T5362	TR5362
Duplex GFCI	SGF20	GFRST20	GFNT2	2097
Duplex GFCI tamper resistant	TRSGF20	GFTRST20	GFTR2	2097TR

Duplex GFCI weather resistant	WRSGF20	GFRWR20	GFWT2	2097TRWR
Duplex GFCI weather resistant, tamper resistant	WRSGF20	GFRTW20	GFWR2	2097TRWR
Duplex isolated ground	IG5362	IG20CR	5362-IG	IG5362
Duplex tamper resistant with USB-A and USB-C charging ports	TRUSBAC20	USB20AC5	T5833	TR20USBAC6
Duplex TVSS	5362S	HBL5362SA	7380	5362SP
Clock hanger	775V	RR151CHI	688	S3713

2.5 WALL PLATES AND COVERS

A. Wall Plates: Comply with UL 514D.
   1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
   2. Screws: Metal with slotted heads finished to match wall plate finish.

B. Wall Plates for Flush Devices: Type 302 or 304, satin finished stainless steel, minimum thickness 0.03 inches.

C. Weatherproof Receptacle Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

C. Verify that wall openings are neatly cut and will be completely covered by wall plates.

D. Verify that final surface finishes are complete, including painting.

E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

F. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

A. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of wiring devices provided under this section.
   1. Provide minimum of 24 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.
   2. Where multiple devices are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
   3. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.

B. Install wiring devices in accordance with manufacturer's instructions.

C. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

D. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.

E. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

F. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices unless otherwise indicated.

G. Install wiring devices plumb and level with mounting yoke held rigidly in place.

H. Install wall switches with OFF position down.

I. Install vertically mounted receptacles with grounding pole on bottom.

J. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

K. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

L. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas and above accessible ceilings.

3.4 FIELD QUALITY CONTROL

A. Inspect each wiring device for damage and defects.

B. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.

C. Test each receptacle to verify operation and proper polarity.

D. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.

E. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.5 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.6 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Fuses.

1.2 REFERENCE STANDARDS

A. NEMA FU 1 - Low Voltage Cartridge Fuses.

B. NFPA 70 - National Electrical Code.

C. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Bussmann, a division of Eaton Corporation: www.cooperindustries.com/#sle.

B. Littelfuse, Inc: www.littelfuse.com/#sle.

C. Mersen: ep-us.mersen.com/#sle.

2.2 APPLICATIONS

A. Fuses 600 Amps or Smaller: Class RK1, time delay, equivalent to Bussmann Low Peak. Provide with open fuse indication where avialable.

2.3 FUSES

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.

C. Provide fuses of the same type, rating, and manufacturer within the same switch.

D. Comply with UL 248-1.

E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.

F. Voltage Rating: Suitable for circuit voltage.

G. Provide the following accessories where indicated or where required to complete installation:
   1. Fuseholders: Compatible with indicated fuses.
   2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.

B. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Do not install fuses until circuits are ready to be energized.

B. For motor circuits, provide fuses rated at 125 percent of motor nameplate full load current.

C. Install fuses with label oriented such that manufacturer, type, and size are easily read.

END OF SECTION

SECTION 26 28 16.16

ENCLOSED SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Enclosed safety switches.

1.2 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction.

B. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. NEMA BS 31047 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).

D. NFPA 70 - National Electrical Code.

E. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

F. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.

G. UL 98 - Enclosed and Dead-Front Switches.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
4. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.

B. Project Record Documents: Record actual locations of enclosed switches.

C. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. ABB/GE: www.electrification.us.abb.com.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier, where possible.

2.2 ENCLOSED SAFETY SWITCHES

A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature: Between -22 degrees F and 104 degrees F.

D. Horsepower Rating: Suitable for connected load.

E. Voltage Rating: Suitable for circuit voltage.

F. Provide with switch blade contact position that is visible when the cover is open.

G. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
   1. Switches 600 Amps or smaller: Class R.

H. Conductor Terminations: Suitable for use with the conductors to be installed.

I. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.

J. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.

K. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
   2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.

L. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

M. Heavy Duty Switches:
   1. Comply with NEMA BS 31047.
   2. Conductor Terminations:
      a. Provide mechanical lugs unless otherwise indicated.
      b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.

N. Provide the following features and accessories where indicated or where required to complete installation:
   1. Auxiliary Switch: SPDT switch suitable for connection to system indicated, with auxiliary contact operation before switch blades open and after switch blades close.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed safety switches.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

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

B. Perform work in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Provide required support and attachment in accordance with Section 26 05 29.

E. Install enclosed switches plumb.

F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

G. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 60 inches above the floor or working platform.

H. Provide grounding and bonding in accordance with Section 26 05 26.

I. Provide fuses complying with Section 26 28 13 for fusible switches as indicated or as required by equipment manufacturer's recommendations.

J. Identify enclosed switches in accordance with Section 26 05 53.

K. Install fuses in fusible disconnect switches.

L. Bolt closed exterior grade level enclosures.

3.3 FIELD QUALITY CONTROL

A. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 26 43 00

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Surge protective devices for branch panelboard locations.

1.2 ABBREVIATIONS AND ACRONYMS

A. SPD: Surge Protective Device.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction.

C. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

D. NFPA 70 - National Electrical Code.

E. UL 1449 - Standard for Surge Protective Devices.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate size and location of overcurrent device compatible with the actual surge protective device and location to be installed. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to ordering equipment.

1.4 SUBMITTALS

A. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.

B. Specification Compliance Review: See Section 26 04 00 - Common Requirements for Electrical, for requirements.

C. Certificates: Manufacturer's documentation of listing for compliance with the following standards:
1. UL 1449.

D. Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.

E. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in accordance with manufacturer's written instructions.

1.7 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.8 WARRANTY

A. Manufacturer's Warranty: Provide minimum five year warranty covering repair or replacement of surge protective devices showing evidence of failure due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Factory-installed, Internally Mounted Surge Protective Devices:
   1. Same as manufacturer of equipment containing surge protective device, to provide complete listed assembly including SPD.

2.2 SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS

A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the drawings.

B. Unless otherwise indicated, provide field-installed, externally-mounted SPDs.

C. List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.

D. Surge Protection Technology: Metal oxide varistor technology. Silicone avalanche diode technology is not acceptable.

E. Protected Modes:
   1. Wye Systems: L-N, L-G, N-G, L-L.

F. UL 1449 Voltage Protection Ratings (VPRs):
   1. 208Y/120V System Voltage: Not more than 700 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
   2. 480Y/277V System Voltage: Not more than 1 200 V for L-N, L-G, and N-G modes and 2,000 V for L-L mode.

G. UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.

H. Fuses, if used, shall allow rated surge current to flow through the device.

I. Enclosure Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
   1. Indoor clean, dry locations: Type 1.

2.3 SURGE PROTECTIVE DEVICES FOR BRANCH PANELBOARD LOCATIONS

A. Surge Protective Device:
   1. Protection Circuits: Field-replaceable modular or non-modular.
   2. Surge Current Rating: Not less than 25 kA per mode/50 kA per phase.
   3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
   4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the short circuit current rating of the equipment the SPD is connected to, including any series ratings.
   5. Diagnostics:
      a. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
      b. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
   6. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch or not direct bus connected.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.

B. Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of drawings and manufacturer's instructions.

C. Verify system grounding and bonding is in accordance with Section 26 05 26, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship).

B. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

C. Provide conductors with minimum ampacity as indicated on the drawings, as required by NFPA 70, and not less than manufacturer's recommended minimum conductor size.

D. Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance.

E. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 05 26 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

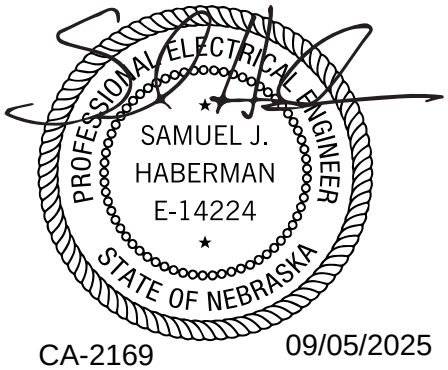
F. Disconnect SPD prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPD connected.

3.3 FIELD QUALITY CONTROL

A. Perform startup inspection and testing in accordance with manufacturer's instructions.

B. Repair or replace malfunctioning units. Retest after repairs or replacements are made.

END OF SECTION



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