

PROJECT MANUAL / SPECIFICATIONS FOR

TUCKAHOE MIDDLE SCHOOL HIGH SCHOOL RECONSTRUCTION

65 Siwanoy Blvd. Eastchester, NY 10709

NY SED Project Control No: 66-03-02-03-0-002-024

KG+D Project No: 2021-1053

TUCKAHOE UNION FREE SCHOOL DISTRICT

65 Siwanoy Blvd. Eastchester, NY 10709

ARCHITECT:

KG+D ARCHITECTS, PC

285 Main Street
Mount Kisco, NY 10549

SYSTEMS ENGINEER:

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STRUCTURAL ENGINEER:

THE DISALVO ENGINEERING GROUP

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ASBESTOS DESIGNER:

OMEGA ENVIRONMENTAL SERVICES, INC.

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South Hackensack, NJ 07606

SPECIFICATIONS:

SUE MCCLYMONDS

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Amsterdam, NY 12010

CONSTRUCTION DOCUMENTS

31 March 2022

TABLE OF CONTENTS

VOLUME 1

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

001000	ADVERTISEMENT FOR BIDS
002100	INVITATION AND INSTRUCTIONS TO BIDDERS
003100	INFORMATION AVAILABLE TO BIDDERS
003113	HAZARDOUS MATERIAL REPORT
004100	PROPOSAL FORM
004513	BIDDER QUALIFICATION STATEMENT
004643	WAGE AND HOUR RATES
005000	CONTRACT AGREEMENT FORMS – AIA A132
006100	BOND REQUIREMENTS
006101	ACCEPTABLE BONDING COMPANY RATINGS
006102	AIA A310 - BID BOND FORM
006103	AIA A312 - BOND FORMS - PERFORMANCE BOND
006104	AIA A312 – BOND FORMS – LABOR AND MATERIAL PAYMENT BOND
007000	GENERAL CONDITIONS – AIA A232
007002	INSURANCE RIDER

DIVISION 01 - GENERAL REQUIREMENTS

011000	DESCRIPTION OF WORK
011001	CONSTRUCTION IMPLEMENTATION PLAN
011100	MILESTONE SCHEDULE
011501	SPECIAL PROJECT REQUIREMENTS - EXCERPTS FROM 8 NYCRR SECTION 155.5 AS THEY ADDRESS “GENERAL SAFETY AND SECURITY STANDARDS FOR CONSTRUCTION PROJECTS”.
012300	ALTERNATES
012500	PRODUCT OPTIONS AND SUBSTITUTIONS
012501	SUBSTITUTION REQUEST FORM
012900	APPLICATIONS FOR PAYMENT
012901	PAYROLL CERTIFICATION
012902	WAIVER OF LIENS FORM
013113	PROJECT COORDINATION
013114	COORDINATION DRAWINGS AND PROCEDURES
013115	REQUESTS FOR INFORMATION (RFI)
013116	RFI FORM
013119	PROJECT MEETINGS
013200	SCHEDULING AND PROGRESS
013300	SUBMITTAL REQUIREMENTS
013301	SUBMITTAL COVER SHEET
013302	REQUEST FOR ELECTRONIC FILES/CAD FILE PROTOCOLS
013306	CERTIFICATION OF SPECIFICATION COMPLIANCE
013529	HEALTH AND SAFETY PLAN (HASP)
014100	PERMITS AND COMPLIANCE
014219	CODES AND STANDARDS
014326	TESTING LABORATORY SERVICES
014329	SPECIAL INSPECTIONS AND TESTS

014330	NYSED STATEMENT OF SPECIAL INSPECTIONS
015000	TEMPORARY FACILITIES
015713	TEMPORARY EROSION AND SEDIMENT CONTROL
015719	ENVIRONMENTAL PROTECTION DURING CONSTRUCTION
016100	MATERIAL AND EQUIPMENT
017123	FIELD ENGINEERING
017329	CUTTING AND PATCHING
017400	CLEANING
017419	CONSTRUCTION WASTE MANAGEMENT
017700	PROJECT CLOSE OUT
017703	LABOR-MATERIALS AFFIDAVIT
017704	DAILY/WEEKLY WAGE AFFIDAVIT
017719	PROJECT RECORD DOCUMENTS
017823	OPERATION AND MAINTENANCE REQUIREMENTS

DIVISION 02 - EXISTING CONDITIONS

024119	SELECTIVE STRUCTURE DEMOLITION AND REMOVALS
--------	---

DIVISION 03 – CONCRETE

033000	CAST-IN-PLACE CONCRETE
035416	HYDRAULIC CEMENT UNDERLAYMENT

DIVISION 04 - MASONRY

042000	UNIT MASONRY
042120	MASONRY REPLACEMENT WORK
047200	CAST STONE
049100	MASONRY CLEANING
049110	MASONRY REPOINTING

DIVISION 05 - METALS

050133	MAINTENANCE OF STEEL LINTELS
051200	STRUCTURAL STEEL FRAMING
053100	STEEL DECKING
054000	COLD-FORMED METAL FRAMING
055000	METAL FABRICATIONS
055313	DECORATIVE METAL RAILINGS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

061053	MISCELLANEOUS ROUGH CARPENTRY
064020	INTERIOR ARCHITECTURAL WOODWORK

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

078413	PENETRATION FIRESTOPPING
078446	FIRE-RESISTIVE JOINT SYSTEMS
079200	JOINT SEALANTS

DIVISION 08 - OPENINGS

081113	HOLLOW METAL DOORS AND FRAMES
081416	FLUSH WOOD DOORS
082250	POLYESTER FACED DOORS
083113	ACCESS DOORS AND FRAMES
084113	ALUMINUM ENTRANCES AND STOREFRONTS
087100	DOOR HARDWARE
087101	DOOR HARDWARE SETS
088000	GLAZING

DIVISION 09 - FINISHES

092116.23	GYPSUM BOARD SHAFT WALL ASSEMBLIES
092150	GYPSUM PLASTER REPAIR AND RESTORATION
092216	NON-STRUCTURAL METAL FRAMING
092800	GLASS-REINFORCED GYPSUM FABRICATIONS
092900	GYPSUM BOARD
093100	CERAMIC TILING
095113	ACOUSTICAL PANEL CEILINGS
095429	WOOD PLANK CEILING SYSTEMS
096400	WOOD FLOORING
096466	WOOD ATHLETIC FLOORING
096500	RESILIENT FLOORING AND ACCESSORIES
096616	PORTLAND CEMENT TERRAZZO FLOORING RESTORATION
096813	TILE CARPETING
097719	WOOD VENEER WALL PANEL SYSTEM
099100	PAINTING

DIVISION 10 - SPECIALTIES

101000	VISUAL DISPLAY SURFACES
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DIVISION 11 – EQUIPMENT - not used

DIVISION 12 – FURNISHINGS

122413 ROLLER WINDOW SHADES
123661 SIMULATED STONE COUNTERTOPS

DIVISION 13 – 22 not used

VOLUME 2

DIVISION 23 – HEATING VENTILATION & AIR CONDITONING

230500 COMMON WORK RESULTS FOR HVAC
230513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
230517 SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
230519 METERS AND GAGES FOR HVAC PIPING
230529 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
230553 IDENTIFICATION FOR HVAC PIPING EQUIPMENT
230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC
230713 HVAC DUCTWORK INSULATION
230719 HVAC PIPING INSULATION
230800 COMMISSIONING OF HVAC
230901 DIRECT DIGITAL CONTROL EQUIPMENT
230993 SEQUENCE OF OPERATION
232213 STEAM AND CONDENSATE HEATING PIPING
232216 STEAM AND CONDENSATE HEATING PIPING SPECIALTIES
232300 REFRIGERANT PIPING
233113 METAL DUCTS
233300 AIR DUCT ACCESSORIES
233600 AIR TERMINAL UNITS
237416 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS
237433 DEDICATED OUTDOOR-AIR UNITS
238129 VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

DIVISION 26 - ELECTRICAL

260519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
260529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
260533 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
260544 SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND
CABLING
260553 IDENTIFICATION FOR ELECTRICAL SYSTEMS
260923 LIGHTING CONTROL DEVICES
260943.16 ADDRESSABLE-LUMINAIRE LIGHTING CONTROLS
262416 PANELBOARDS
262726 WIRING DEVICES
262813 FUSES
262816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
264313 SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

265119	LED INTERIOR LIGHTING
265219	EMERGENCY AND EXIT LIGHTING
265619	EXTERIOR LIGHTING

DIVISION 27 – COMMUNICATIONS

270553	IDENTIFICATION FOR COMMUNICATIONS SYSTEMS
271513	COMMUNICATIONS COPPER HORIZONTAL CABLING

DIVISION 28 – ELECTRONIC SAFETY & SECURITY

280513	CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY
283111	DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

END OF TABLE OF CONTENTS

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. These basic Mechanical Requirements apply to all Division 23 Sections.
- B. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all HVAC and related work for this project, as required by the contract documents.

1.2 RELATED DOCUMENTS

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

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER RESPECTIVE SECTIONS OF THIS DIVISION

- A. Motor starters shall be furnished under this Division. Refer to Specification Section 230513 Common motor requirements for HVAC equipment" for technical information.

1.4 REFERENCES

- A. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers Guides and Standards, latest editions.
- B. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
- C. ASME - American Society of Mechanical Engineers.
- D. UL - Underwriters Laboratory.
- E. NFPA - National Fire Protection Association.

1.5 REGULATORY REQUIREMENTS

- A. Conform to New York State Building Codes and Energy Code as well as all local codes.
- B. Mechanical: Conform to New York State Mechanical, Fuel Gas and Plumbing Code.
- C. Obtain permits, and request inspections from authority having jurisdiction.
- D. NY State Education Department Facility Guidelines

1.6 QUALITY ASSURANCE

- A. The Contractor shall have the work indicated on the drawings and/or specified in each section performed by vendors or mechanics experienced and skilled in its implantation or by a "Specialist", "Specialty Contractor" or "Specialty Subcontractor" under contractual agreement with the Contractor. These terms mean an individual or firm of established reputation, or, if newly organized, whose personnel have previously established a reputation in the same field, which is regularly engaged in, and which maintains a regular force of workmen skilled in either manufacturing or fabricating items required by the Contract, installing items required by the Contract, or otherwise performing work required by the Contract.
- B. Where the Contract Specifications require installation by a "Specialist," that term shall also be deemed to mean either the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform such work under the manufacturer's direct supervision.

1.7 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed arrangement of Work to meet Project conditions, including changes to Work specified in other Sections.

1.8 SCOPE OF WORK

- A. This Contractor shall be responsible for coordinating his work with all other trades.
- B. The Contractor shall provide all materials, labor, equipment, tools, appliances, services, hoisting, scaffolding, supervision and overhead for the furnishing and installing of all Plumbing work indicated on plan and in the specifications and related work including but not limited to the following:
 - 1. Demolition of existing work including, piping, sheet metal work, miscellaneous equipment, fans, air-handlers, and roof top units.
 - 2. Packaged RTUs – Cooling only.
 - 3. Packaged RTUs – Heat Pump.
 - 4. VRF heat recovery systems.
 - 5. Dedicated outdoor air system
 - 6. Steam and condensate Piping and specialties
 - 7. Fans.
 - 8. Ductwork and specialties.
 - 9. Pipe and duct insulation.
 - 10. New VAV boxes
 - 11. Equipment Supports
 - 12. Automatic temperature controls.
 - 13. Grilles, registers, louvers, and diffusers.
 - 14. Vibration isolation.
 - 15. Equipment supports.
 - 16. Motor starters and disconnects.
 - 17. Protection.

18. Identification.
19. Coordination.
20. Phasing.
21. Rigging.
22. Testing and Balancing Reports Air and Water.
23. Shop Drawings.
24. As-Built Drawings and Maintenance Manuals.
25. Warranties.
26. Commissioning.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 GENERAL

- A. Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.
- B. Construct all equipment in accordance with requirements of all applicable codes. All pressure vessels and safety devices that fall within the scope of the ASME Code shall conform to the Code and bear the ASME label or stamp.
- C. Match and balance all system components to achieve compatibility of equipment or satisfactory operation and performance throughout the entire operating temperature and control ranges. All installations shall be in accordance with manufacturer's recommendations.
- D. Provide all controls, wiring, piping, valves, accessories and other components necessary to make all systems complete and operable.
- E. The contractor shall warranty all work, including labor and materials, and equipment furnished and installed as part of this contract for a minimum period of year from the date of acceptance by the owner, in writing. Certain equipment, such as underground fuel tanks, may have longer warranties as indicated in the specifications. In such cases the longer of the two warranties shall prevail.

3.2 SHOP DRAWINGS AND SUBMITTALS (COORDINATE WITH DIVISION 1)

- A. Shop drawings and samples shall be prepared and submitted in accordance with the requirements established in the contract and shall consist of the all items listed in the following paragraphs.
- B. Manufacturer's data or shop drawings giving full information as to dimensions, materials, and all information pertinent to the adequacy of the submitted equipment shall be submitted for review. Shop drawings shall include, but not be limited to the following:

- C. Submit all Mechanical equipment noted and scheduled on plans including but not limited to the following:
1. Automatic Temperature Controls, Operation Sequences & Wiring Diagrams, and Control Diagrams hardware and software
 2. Motor Starters and Controllers
 3. Air handling units and curbs
 4. Vibration isolation
 5. Fans
 6. Hangers and Inserts
 7. Equipment Supports and Vibration Eliminators
 8. Sheet Metal Construction Standards
 9. Piping Layout (1/4 scale)
 10. Ductwork Layout (1/4 scale)
 11. Insulation (piping and ductwork)
 12. Piping, Valves, fittings, and Specialties
 13. Filters
 14. Fan Curves and Sound Rating
 15. Coils
 16. Fire dampers, Motorized Dampers, Smoke dampers
 17. Diffusers Registers and Grilles
 18. Balancing Reports, Air and Water
 19. Coordinated Composite Drawings with Piping, Ductwork, Conduits, Lights, registers Grilles and Smoke Detectors, etc.
- D. The contractor shall, upon award, submit a schedule for the engineers review indicating when each of the above shop drawings shall be submitted. Submittals shall be made in a timely manner as the project progresses in accordance with the Construction manager or General contractor's work schedules. The contractor shall allow sufficient time for the engineers to perform his review. A minimum of 10 business days shall be required. Untimely submittals shall be cause for the owner to make a delay against the contractor.
- E. Demolition, purchase and or installation shall not begin until shop drawings pertaining to the equipment associated with any related portion of the work have been submitted.
- F. Sheet metal shop drawings shall indicate all existing and/or new lights, walls, piping, structural elements, existing work, etc. and dimension locations of ductwork including elevations in relation to these items.
- G. Where shop drawings have been reviewed by the Engineer, such review shall not be considered as a guarantee of measurements or building conditions. Where drawings have been reviewed, said review does not mean that drawings have been checked in detail; said review does not substantiate any quantities and in any way relieve the Contractor from his responsibility nor the necessity of furnishing materials or performing work required by the Contract Drawings and Specifications. It does not relieve the contractor of the responsibility to perform all work to accepted industry standards and in a code compliant manner. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

- H. Where substitutions are submitted for approval the review shall be for general performance comparison to the specified product. Products shall not be reviewed for size, clearance or coordination with other trades. Coordination with other trades shall be the responsibility of the contractor. And changes to existing conditions or changes required to the work of other trades such as a result of substituted material or equipment approved or not shall be the responsibility of this contractor.
- I. Approval of shop drawings
 - 1. The Contractor shall be specifically responsible for checking equipment dimensions and clearances and confirming that equipment will fit into the designated space and connect properly to adjoining equipment and/or materials.
 - 2. Submittals marked "Make Corrections Noted" give authority to proceed in accordance with the notes. However, if drawings are also marked "Amend and Resubmit", corrected drawings must be resubmitted for final review.
 - 3. Submittals marked "Rejected" do not give authority to proceed with any portion of the work shown there-on. Drawings must be resubmitted.
 - 4. Submittals marked "Rejected" or "Amend and Resubmit" shall include a specific written response to the engineer's comments. Resubmission of a submittal without a written response to the engineer's comments will be considered incomplete and shall be returned un-reviewed.
- J. The contractor shall submit a composite shop drawing layout plan. This shall include all trades including plumbing mechanical and electrical trades. It shall indicate all equipment, piping conduit. It shall include an accurate architectural background. The composite drawing is for contractors and subcontractors to coordinate their work with the work of other trades prior to submitting to the engineer for review and approval. Identify equipment clearances as required for service and maintenance by the manufacture. Indicate conflicts for resolution.
- K. Coordination submittals for piping, conduit and equipment within the building shall be made using 3-D software such as Autocad and shall include plan view sections and elevations as necessary to full illustrate and evaluate and resolve all structural, piping, major conduit and equipment for conflicts with other trades.

3.3 CHARTS AND TAGS

- A. The Contractor shall provide three sets of charts and diagrams of all piping systems indicating the number and location of valves, controls, etc.
- B. All valves, dampers, and controls shall be designated with brass tags. Refer to section 23 05 23 Identification for HVAC Piping and equipment
- C. General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

3.4 CODES AND STANDARDS

- A. All equipment and installation methods shall conform to the applicable standards and/or recommendations set forth in the New York State Building Code, Local Codes as well as all Codes and Standards listed in the general requirements sections of the specification.

3.5 FEES & PERMITS

- A. The Contractor shall obtain all permits and pay all fees required related to this scope of work

3.6 PAINTING

- A. All motors, fans and all other factory manufactured and assembled apparatus shall be factory coated with one coat of primer and one coat of machinery enamel standard color at the factory and after installation, all finishes shall be cleaned and touched up to repair any damage incurred during construction.
- B. All piping shall be painted in colors conforming with OSHA Standards. All new and existing exposed iron and supplementary dunnage steel shall be finished according to specifications.
- C. All supports, nuts, bolts and hanger fasteners located outside shall be galvanized or nickel plated.

3.7 RIGGING

- A. Furnish all labor, materials and equipment required to rig equipment and materials.
- B. The rigger shall secure any necessary permits and comply with all applicable Federal, State and local safety regulations. A copy of permits to be kept at both the project site and Engineer's Office.
- C. The rigger shall have a minimum of five (5) years of practical experience and hold a master riggers license if required.
- D. The procedure for rigging shall be submitted to the Engineer for review. All possible precautions should be taken to prevent damage to the structure, streets, sidewalks, curbs, lawns, etc.

3.8 CUTTING AND PATCHING

- A. All cutting and patching required for piping, ductwork, control conduits, etc., passing through walls, floors, and roof shall be provided by the this Contractor under this contract unless otherwise noted. This Contractor shall be responsible for any damage done to the structure due to his negligence.

- B. Patching materials and application shall match existing construction. It also includes patch to match any voids left behind by HVAC removals. MC will hire a skilled tradesman (mason, carpenter, etc.) to perform this work.
- C. Where applicable, new holes for piping installation shall be core drilled.
- D. Pipe Sleeves & Fire-stopping:
 - 1. Provide for all pipes, conduits ducts, and other elements passing through floors, walls, partitions and structural elements, sleeves as specified. Sleeves shall be of adequate diameter to allow for a minimum of 3/4 inches clear all around sleeve and pipe. When pipe, conduit ducts or other such element penetrates other than fire rated assembly and is insulated, insulation shall pass continuously through sleeves with 1/2 inch clearance between insulation and sleeve.
 - 2. Where pipes, conduits and other such elements penetrate fire rated assemblies, or where holes or voids are created to extend mechanical systems through fire rated assemblies (walls, floors, ceilings, structure, etc.); sleeves and fire-stopping systems shall be installed.
- E. Furnish access doors, to the General Contractor for installation where required in finished walls, partitions and the like for access to junction boxes, controls, valves, etc, concealed behind finished construction.
- F. Submit location drawings and sizes for review prior to installation.

3.9 PROTECTION-COORDINATE WITH DIVISION 1

- A. Special protection is required for installation of a Derrick or other device for rigging purposes. This Contractor shall coordinate with the rigger to facilitate rigging work.
- B. Recommendations and Provisions of ANSI Bulletin A10.2 and OSHA shall be complied with in-so-far as applicable to the work.
- C. The Contractor shall provide temporary partitions or tarpaulins to protect adjacent spaces and/or equipment. He shall be responsible for any damage or injury to person or property of any character resulting from any act, omission, neglect or misconduct in his manner or method of executing his work.
- D. The Contractor shall restore at his own expense such property to a condition similar or equal to that existing before such damage or injury in an acceptable manner.
- E. The Contractor, furthermore, shall conduct his operations in such a manner as to prevent dust and debris from transferring on to adjoining property or into existing spaces.

- F. All openings cut in walls, floors, roof or ceilings of the building, for conduit, pipe, ductwork, etc., shall be closed off with box-type temporary protective enclosures of ¼" tempered hardboard, except when mechanics are actually working at the particular opening. Enclosures shall be constructed of fireproof 2x4 frame, four (4) sides covered and made completely dust and water tight.
- G. All finished floor areas through which the contractor must pass with materials or equipment shall be protected with a layer of ¼" hardboard, "Masonite", "Ramboard" laid with joints taped together.
- H. The roof shall be protected with ½" plywood in all areas of work.

3.10 EQUIPMENT SUPPORTS

- A. A. Provide supplementary steel dunnage, curbs, angle iron stands, etc., to properly set and install all equipment, including supports necessary to properly pitch piping.
- B. Existing dunnage shall be supplemented with angle iron supports and cross members as required to support new equipment at all supports point or continuously as recommended by the manufacture. Provide spring isolators under all new dunnage mounted equipment.

3.11 WELDING

- A. A. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.
- B. The handling and storage of all welding materials, acetylene and oxygen tanks, burners, and other equipment required for the execution of welding and cutting work shall be subject at all times to the approval of the Owner and/or Architect. All welding materials and gas tanks shall be promptly removed from the premises upon completion of each day's work or stored in a manner satisfactory to the owner. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.
- C. Provide all temporary ventilation , and ventilation air systems required during welding operations as required by OSHA.

3.12 AS-BUILT DRAWINGS

- A. The Contractor shall provide a complete set of As-Built drawings showing actual installation and locations of all new and existing equipment, piping, and ductwork in the entire building. Schedules shall be revised to indicate actual equipment installed.
- B. As-Built drawings shall be submitted as per contract requirements in accordance with Division 1 and shall be submitted in paper format for review. Accepted as built shall then be submitted in AutoCAD format on hard disc.

3.13 CONDITIONS

- A. Inspection: Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence. Verify that the work of this Section may be completed in strict accordance with all pertinent codes and regulations, the approved Shop Drawings, and the Manufacturers' recommendations.
- B. Discrepancies: In the event of discrepancy, immediately notify the Engineer. Do not proceed in areas of discrepancy until all such discrepancies have been fully resolved.

3.14 INSTALLATION OF EQUIPMENT

- A. Locations: Install all equipment in the locations shown on the approved Shop Drawings except where specifically otherwise approved on the job by the Owner and/or Engineer.
- B. Interferences: Avoid interference with structure, and with work of other trades, preserving adequate headroom and clearing all doors and passageways to the approval of the Engineer.
- C. Inspection: Check each piece of equipment in the system for defects, verifying that all parts are properly furnished and installed, and that all items function properly, and that all adjustments have been made.

3.15 CLOSING-IN OF UNINSPECTED WORK

- A. General: Do not allow or cause any of the work to be covered up or enclosed until it has been inspected, tested, and accepted by the Engineer and by all other authorities having jurisdiction.
- B. Uncovering: Should any of the work of this Section be covered up or enclosed before it has been completely inspected, tested, and approved, do all things necessary to uncover all such work. After the work has been completely inspected, tested, and approved, provide all materials and labor necessary and make all repairs necessary to restore the work to its original and proper condition at no additional cost to the owner.

3.16 BUILDING ACCESS

- A. The Contractor shall inform himself fully regarding peculiarities and limitations of space available for the passage and installation of all equipment and materials under the Contract.
- B. Verify and coordinate removal of existing construction and/or knock-down of equipment to suit conditions. Special attention should be given to equipment installation. Provide all labor and material to facilitate installation.

3.17 COOPERATION WITH OTHER TRADES PHASING

- A. Cooperate with other trades in order that all systems in the work may be installed in the best arrangements.
- B. Coordinate as required with all other trades to share space in common areas and to provide the maximum of access to each system.
- C. This Contractor shall submit fully coordinated shop drawings showing all piping, ductwork and equipment, as well as relevant work of all other trades such as light, conduits, structural and steel, which may impact the final size or placement of piping, ductwork, equipment, diffusers and grilles.
- D. The work shall be scheduled and phased in accordance with the requirements of the contract and the client. Prior to the commencement of work the HVAC contractor shall submit a schedule in writing to the Architect and owner for approval. There shall be no shut downs of any systems without prior written approval from the owner. The contractor shall include in his bid all costs associated with providing temporarily piping controls, ductwork and fans and air conditioning units to maintain operations in the phase II area while work is being performed on the Phase I area. It shall also be noted that ductwork, piping and controls will have to be extended through the phase II work areas in order to reach the area(s) under construction in phase I as part of this work. The contractor shall include in his bid all provisions to perform such phasing work

3.18 CLEANING

- A. It is the intent of the contract documents that all work, including the inside of equipment be left in a clean condition. All construction dirt shall be removed from material and equipment.
- B. All removed items shall be taken off the premises and discarded in a manner satisfactory to the Owner.

3.19 COMPLETENESS

- A. It is the intent of the contract documents to provide complete systems. Completeness shall mean not only that all material and equipment has been installed properly, but that all material and equipment is installed, adjusted, and operating as per the design intent in the opinion of the Engineer and in accordance with generally accepted industry good practice.

3.20 FIRE PREVENTION DURING HOT WORK

- A. Before starting operations, the Contractor shall furnish trained personnel to provide fire watches for locations where hot work is to be performed. One fire watcher may observe several locations in a relatively small contiguous area. Contractor shall furnish suitable type, fully-charged, operable portable fire extinguisher to each fire watcher.
- B. The Contractor shall provide fire watchers who know how to operate the fire extinguisher, how to turn on a fire alarm and how to summon the fire department.

- C. Before starting operations, take suitable precautions to minimize the hazard of a fire communicating to the opposite side of walls, floors, ceilings and roofs from the operations.

3.21 SAFETY MEASURES

- A. Hot work shall not be done in or near rooms or areas where flammable liquids or explosive vapors are present or thought to be present. A combustible gas indicator (explosimeter) test shall be conducted to assure that each area is safe. The Contractor is responsible for arranging and paying for each test.
- B. Insofar as possible, the Contractor shall remove and keep the area free from all combustibles, including rubbish, paper and waste within a radius of 25 feet from hot operations.
- C. If combustible material cannot be removed, the Contractor shall furnish fireproof blankets to cover such materials. At the direction of the owner floors, walls, and ceilings of combustible material shall be wetted thoroughly with water before, during, and after operations sufficiently to afford adequate protection.
- D. Where possible, the Contractor shall furnish and use baffles of metal or gypsum board to prevent the spraying of sparks, hot slag and other hot particles into surrounding combustible material.
- E. The Contractor shall prevent the spread of sparks and particles of hot metal through open windows, doors, and holes and cracks in floors, walls, ceilings and roofs.
- F. Cylinders of gas used in hot work shall be placed a safe distance from the work. The Contractor shall provide hoses and equipment free of deterioration, malfunction and leaks. Suitable supports shall be provided to prevent accidental overturning of cylinders. All cylinder control valves shall be shut off while in use with the gas pressure regulator set at 15 psi or less.
- G. When hot work operations are completed or ended for the day, each location of the days work shall be inspected by the Contractor 30 to 60 minutes after completion of operations to detect for hidden or smoldering fires and to ensure that proper housekeeping is maintained. Contractor shall cleanup the area of work at the end of each shift or workday.
- H. Where sprinkler protection exists, the sprinkler system shall be maintained without interruption while operations are being performed. If operations are performed close to automatic sprinkler heads, gypsum board sheets or damp cloth guards may be used to shield the individual heads temporarily. The heads shall be inspected by the Contractor immediately after hot work operations cease, to ensure all materials have been removed from the heads and that the heads have not been damaged.
- I. Suitable type, fully-charged, operable portable fire extinguisher shall be available at all times during hot work operations.

- J. If any of the above safeguards are not employed, or are violated, the Contracting owners Representative may, by written notice, stop the work until compliance is obtained. Such stoppage shall not relieve the Contractor from performing his work within the Contract period for the Contract price.

3.22 USE OF OWNERS EQUIPMENT

- A. The contractor shall not use any the owner's HVAC system or equipment, new or existing, for any purpose. The contractor shall provide temporary hvac equipment, ductwork, power, and controls for use during construction for the purpose of ventilation, or heating during the construction process. All such equipment, ductwork, power, and controls shall be removed and the completion of work.

3.23 CLOSEOUT PROCEDURES

- A. General Operating and Maintenance Instructions: Arrange for each installer of operating equipment and other work that requires regular or continuing maintenance, to meet at the site with the Owner's personnel to provide necessary basic instructions in the proper operation and maintenance of the entire Work. Where installers are not expert in the required procedures, include instruction by the manufacturer's representatives.
- B. Where applicable, provide onsite instruction and training, including application of special coatings systems, at manufacturer's recommendation.
- C. Provide a detailed review of the following items:
 - 1. Maintenance manuals
 - 2. Record documents and catalog cuts for each piece of equipment.
 - 3. Spare parts and materials
 - 4. Tools
 - 5. Lubricants
 - 6. Fuels
 - 7. Identification systems
 - 8. Control sequences
 - 9. Hazards
 - 10. Cleaning
- D. Warranties, bonds, maintenance agreements, and similar continuing commitments.
- E. Demonstrate the following procedures:
 - 1. Start-up
 - 2. Shut-down
 - 3. Emergency operations
 - 4. Noise and vibration adjustments
 - 5. Safety procedures
 - 6. Economy and efficiency adjustments
 - 7. Effective energy utilization.
 - 8. Periodic maintenance

- F. Prepare instruction periods to consist of classroom and or "hands-on" instruction. Provide all equipment including the following.
1. All control systems
 2. All Roof top units
 3. VRF split systems
 4. Dedicated outdoor air systems
 5. Make up air and exhaust systems

Consult individual equipment specification sections for additional training requirements.

- G. Prepare a written agenda for each session and submit for review and approval. Include date, location, purpose, specific scope, proposed attendance and session duration.
- H. Record training sessions in digital format, format as selected by the Owner. Turn over digital files to the Owner after training has been completed.

END OF SECTION 230500

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Division 24 - Equipment Wiring Systems: Electrical characteristics and wiring connections.

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

1.4 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. NEMA MG 1 - Motors and Generators.
- D. NFPA 70 - National Electrical Code.

1.5 REGULATORY REQUIREMENTS

- A. Conform to UL Component Recognition for appropriate sizes.
- B. Conform to NFPA 70 applicable electrical code, Underwriters Laboratories, Inc., and NEMA
- C. Conform to I ECC 2015

1.6 DELIVERY, STORAGE, AND PROTECTION

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

1.7 WARRANTY

- A. Provide five-year manufacturer warranty for all motors larger than ½ horsepower.

PART 2 - PRODUCTS

MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Gould.
 - 2. Century.
 - 3. General Electric.
 - 4. Square D

2.2 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.
- C. All electric motors of sizes and types as specified for driving mechanical equipment shall be provided under this section.
- D. Electrical Service: All motors shall be 60 Hertz unless otherwise noted. Refer to Electrical Specifications for required electrical characteristics.
- E. Motors: Design for continuous operation in 40° C environment, and for temperature rise in accordance with ANSI/NEMA MG limits for insulation class, Service Factor, and motor enclosure type. Motors shall be of sufficient size for duty to be performed.
- F. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency, power factor.
- G. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in end frame. Size motor boxes to receive motor feeders and ground cable indicated on electrical drawing schedules.
- H. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

- I. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 MOTOR EFFICIENCY

- A. Electric motors shall meet the minimum efficiency requirement of the following tables in accordance with International Energy conservation code when tested in accordance with DOE CFR 431. Performance data shall be certified by approved testing agency.
- B. Subtype I motors – NEMA premium efficiency as per table NEMA MG 1 table 12-12 and Energy Conservation code table 405.8(1). This shall apply to general purpose, T-frame, single speed, squirrel cage, induction type; 230/460-V, NEMA Designs A or B, continuous rated, 60 Hz, from 1 to 200 hp, 2-, 4- and 6-pole (3600-, 1800- and 1200-rpm), open and enclosed. Subtype I motors 250 hp to 500 hp motor efficiency shall be able NEMA MG 1 table 12-11 and Energy Conservation Code table 405.8(1).
- C. Subtype II motors – NEMA efficiency as per table NEMA MG 1 table 12-11 and Energy Conservation code table 405.8(2). This shall apply to general purpose motors but can configured as U-frame motors; NEMA Design C motors; close-coupled pump motors; footless motors; vertical solid shaft normal thrust motors (as tested in a horizontal position); eight-pole (900 rpm) motors, and polyphase motors with a voltage of not more than 600 V (other than 230 or 460 V).
- D. Minimum average full load efficiency of polyphase small electric motors up to 3 hp shall be in accordance with Table C405.8(3) of the International Energy Conservation Code
- E. Minimum average full load efficiency for capacitor-start, capacitor-run and capacitor-start induction-run small electric motors up to 3 hp shall be in accordance with Table C405.8(4) of the International Energy Conservation Code.

2.4 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Service Factor: 1.15.
- C. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- D. Multispeed Motors: Separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000

hours. Calculate bearing load with NEMA minimum V-belt pulley with belt centre line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

- G. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
- H. Sound Power Levels: To NEMA MG 1.
- I. Temperature Rise: Match insulation rating.
- J. Insulation: Class B or better.
- K. Code Letter Designation:
 - 1. Motors [15] HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- L. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.5 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Use part winding Start above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- C. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.6 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.

2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve ball bearings.

2.7 POWER FACTOR CORRECTION

- A. Provide a capacitor for each three phase, single speed motor rated 3 HP or larger shall be provided to correct the full load power factor to 95%. The capacitor shall be mounted at the motor for connection across the motor terminals by Electrical Contractor
- B. Capacitors;
1. Capacitors shall be totally enclosed, fused and with discharge resistors.
 2. Capacitors based on nominal motor RPM shall be provided in accordance with the following table to correct power factor to 95% and verify sizes with motor manufacturer.

Motor HP	Capacitor KVAR		Capacitor KVAR	
	3600 RPM Motor		1800 RPM Motor	
3	1.5		1.5	
5	2		2	
7.5	2.5		2.5	
10	3		3	
15	4		4	
20	5		5	
25	6		6	
30	7		7	
40	9		9	
50	12		12	
60	14		14	

2.8 STARTERS

A. GENERAL

1. See specification Section 16485 and Division 1 for additional information.
2. Starters for motors operating at 120 volts shall be manual starters unless otherwise indicated. Starters for motors operating at other than 120 volts shall be magnetic starters.
3. All starters shall be enclosed. Enclosures shall be surface mounted NEMA 1 unless otherwise indicated.
4. Where weatherproof starters are required, the enclosure shall be NEMA 4.
5. It shall be verified that the correct overload heaters have been installed in the starter before energizing any motor. Sizing shall be based on motor nameplate current and taking into account any reduction in current due to power factor correction.
6. Alternate Manufacturers –
 - a. Allen-Bradley
 - b. Crouse-Hinds Co.
 - c. Cutler-Hammer, Inc.
 - d. General Electric Co.
 - e. Square D Co.
 - f. Westinghouse Electric Corp.

B. MANUAL STARTERS

1. Two-pole, toggle operated, thermal overload device in each phase leg, handle guard for padlocking toggle handle and with indicated control and signal devices.
2. Where a motor is controlled automatically by an interlock or pilot device, a "HAND-OFF-AUTO" switch shall be provided in the starter cover. Where the rating of the interlock or pilot device is inadequate to control the motor currents directly, a properly rated contactor shall be provided between the controlling device and the motor.
3. An "ON" pilot light shall be provided in the starter cover.

C. MAGNETIC STARTERS

1. Starters shall be sized in accordance with NEMA standards and the following table, except that starters shall not be smaller than NEMA size 0. Starters shall be provided with one N.O. electrical holding interlock, under voltage protection and two additional auxiliary contacts within the same enclosure. NEMA size starters shall be provided as follows

STARTER	MAX HP
SIZE	AT 460 VOLTS
0	5
1	10
2	25

2. All starters shall be combination type with the starter and disconnect in the same enclosure. All starters shall be Type 2 coordination protected. Fuses shall be Bussman "Low Peak" type or equal sized at 125% of motor nameplate rating. Verify and coordinate requirements for fused disconnect switches with the Electrical Contractor prior to ordering starters.
3. Provide S.S.P.B. or H-O-A switches and pilot light in covers as required to facilitate control operation sequences.

D. CRITICAL FAULT

1. Where starters are not integral to equipment and are furnished and installed separately from equipment by the contractor, provide a 3 phase line voltage monitor by ICM Controls model 450 or approved equal. Unit shall be installed in the motor starter or in a separate enclosure with the same rating as the starter. It shall be arranged to monitor critical faults including phase loss or reversal, and when detected, de-energize the load. It shall monitor non-critical faults including high/low voltage, voltage unbalance and when detected, after a time delay de-energize the load.

PART 3 - EXECUTION

- A. Suitable starting and controlling equipment and devices shall be furnished and installed as specified hereinafter and as shown on the Drawings. The starting equipment shall be arranged, generally, in control groups, or in certain cases, as isolated combination starters as specified or indicated. The Heating Ventilating and Air Conditioning Sequences of Operation, drawings and specifications shall be referred to for the manner of control, operation and monitoring of motors and the electrically operated equipment.
- B. A starter and disconnect switch or combination motor starter disconnect shall be provided for every motor and each and every electrically operated piece of equipment by this contractor except where complete starters and controls are furnished by the manufacturer of the motor or piece of equipment. Starters shall be internally wired to provide the required control operation and monitoring. All control devices such as push buttons, break-glass stations, alternators, relays, pilot lights, etc., shall be provided as required for operation of mechanical equipment. All roof top and remotely located equipment shall have remote starters as located on plan and shall have local disconnect switches. All equipment located in equipment rooms can use combination starters/disconnects located within line of site of controlled equipment. All starters and disconnect switches shall be in enclosures suitable for the environment in which they are installed. Starters and disconnect switches located in machine rooms shall use NEMA 1. Starters and disconnect switches located outdoors shall use NEMA 4x.

Starters and disconnect switches located in machine rooms which are subject to potential water damage shall use NEMA 2

- C. Starting equipment and devices specified in this section (and section 23 29 13 Variable Frequency Controllers), shall be furnished by the mechanical subcontractor and shall be installed by the Electrical subcontractor. In general the mechanical subcontractor shall furnish all motor starters and disconnect switches except where they are an integral part of a motor control center, in this case starters and disconnects shall be provided, (furnished and installed), by the electrical contractor. The Electrical subcontractor shall also provide all wiring necessary to supply power to the electric motors specified under this section, including connections from the starters to the motors. Starters and disconnects shall also include variable frequency drives.
- D. The mechanical Contractor shall furnish and install all wiring between control devices and controlled equipment furnished under this Section, including interlock control wiring between motor starters, and all automatic temperature control wiring. All wiring shall be installed in conformance with applicable codes and the requirements of the Electrical Division of the Specifications.
- E. The Electrical Contractor shall furnish a 120-volt power source to temperature control panels and equipment requiring a separate 120 volt control power source. Power for control circuits for all devices connecting to motor starters shall be obtained from 120-volt control transformers provided in each starter operating at other than 120 volts. Provide transformers for all low voltage control systems as required.
- F. Furnish detailed composite wiring diagrams and such other information necessary to assure the proper connection, operation and control of motorized equipment, including interlocks, automatic controls, safety controls and all auxiliary circuits.
- G. All control units shall be furnished with a nameplate indicating which device or equipment it controls, the voltage. Additional nameplates on each push button, selector switch and pilot light indicating their functions shall be provided. Nameplates shall be laminated phenolic with white letters on black background, minimum 2" high.
- H. All motors supplied either with equipment or installed separately that are to be used in conjunction with variable frequency drive shall be inverter duty motors.

END OF SECTION 230513

SECTION 230517 – SLEEVES AND ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Escutcheons.
 - 6. Floor plates.
 - 7. Acoustic split seal rings

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. Airex Manufacturing.
 3. CALPICO, Inc.
 4. Metraflex Company (The).
 5. Link Seal
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 2. Pressure Plates: Carbon steel or Stainless steel.
 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, or Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. GPT; an EnPro Industries company.
 3. Metraflex Company (The).
 4. Proco Products, Inc.
 5. Fernco
- B. Description: Manufactured heavy rubber or EPDM, sleeve-to-pipe water stop assembly. Unit has rubber water stop collar with center opening to match piping OD. Connected with stainless steel hose clamps. Made for copper or plastic carrier pipes. Size up to 4" sleeve and 3" carrier pipe.

2.4 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Non-shrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 ESCUTCHEONS

- A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- C. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
- D. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.6 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.7 ACOUSTIC SPLIT SEALS

- A. Acoustic Split Seals: consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Grout seals to make it integral with the floor, wall or ceiling in masonry construction. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SPS or SWS as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls. Sleeves for building service piping entering the building shall be one nominal line size larger than the service pipe.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.

- a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
- 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls below or above grade and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.
- C. Coordinate the minimum size of sleeves with the pipe. Sleeves for plumbing piping shall be 2x the diameter of the service pipe.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in above walls at service piping entries into building.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 ESCUTCHEON INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
- b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
- c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

- 1. New Piping: One-piece, floor-plate type.
- 2. Existing Piping: Split-casting, floor-plate type.

3.5 ACOUSTIC SPLIT SEAL

A. Install Acoustic split seals on all hydronic piping 3" and over, penetrating mechanical equipment room walls.

3.6 FIELD QUALITY CONTROL

Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230517

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Bimetallic-actuated thermometers.
 - 2. Filled-system thermometers.
 - 3. Liquid-in-glass thermometers.
 - 4. Light-activated thermometers.
 - 5. Thermowells.
 - 6. Dial-type pressure gages.
 - 7. Gage attachments.
 - 8. Test plugs.
 - 9. Test-plug kits.
 - 10. Sight flow indicators.
 - 11. Orifice flow Meters

- B. Related Sections:

- 1. Section 231123 "Facility Natural-Gas Piping" for gas meters.
 - 2. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 Thermometer Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Terice, H. O. Co.
2. Watts; a Watts Water Technologies company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

2.2 BIMETALLIC-ACTUATED THERMOMETERS

- A. Standard: ASME B40.200.
- B. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
- C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.
- D. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
- F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
- G. Window: Plain glass.
- H. Ring: Stainless steel.
- I. Element: Bimetal coil.
- J. Pointer: Dark-colored metal.
- K. Accuracy: Plus or minus 1 percent of scale range.

2.3 FILLED-SYSTEM THERMOMETERS

- A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 1. Standard: ASME B40.200.
 2. Case: Sealed type, cast aluminum or drawn steel; 5-inch nominal diameter.
 3. Element: Bourdon tube or other type of pressure element.
 4. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
 5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
 6. Pointer: Dark-colored metal.
 7. Window: Glass.
 8. Ring: Stainless steel.
 9. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.

10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
11. Accuracy: Plus, or minus 1 percent of scale range.

2.4 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
 1. Standard: ASME B40.200.
 2. Case: Cast aluminum; 6-inch nominal size.
 3. Case Form: Back angle unless otherwise indicated.
 4. Tube: Glass with magnifying lens and blue or red organic liquid.
 5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
 6. Window: Glass or plastic.
 7. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
 8. Connector: 3/4 inch, with ASME B1.1 screw threads.
 9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 1. Standard: ASME B40.200.
 2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
 3. Case Form: Adjustable angle Back angle unless otherwise indicated.
 4. Tube: Glass with magnifying lens and blue or red organic liquid.
 5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
 6. Window: Glass.
 7. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
 8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
 9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.5 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.6 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.7 PRESSURE GAGES

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

- a. Terice, H. O. Co.
- b. Watts; a Watts Water Technologies company.
- c. Weiss Instruments, Inc.
- d. Weksler Glass Thermometer Corp.

B. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.
2. Case: Liquid-filled Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.8 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass or stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.
- C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.9 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Terice, H. O. Co.
 - 2. Watts; a Watts Water Technologies company.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Glass Thermometer Corp.
- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: EPDM self-sealing rubber.

2.10 TEST-PLUG KITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Sisco Manufacturing Company, Inc.
 - 2. Terice, H. O. Co.
 - 3. Watts; a Watts Water Technologies company.
 - 4. Weiss Instruments, Inc.
- B. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

- D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.
- E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.
- F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install remote-mounted pressure gages on panel.
- J. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- K. Install valve and syphon fitting in piping for each pressure gage for steam.
- L. Install test plugs in piping tees.
- M. Install flow indicators in piping systems in accessible positions for easy viewing.
- N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- O. Install flowmeter elements in accessible positions in piping systems.
- P. Install wafer-orifice flowmeter elements between pipe flanges.

- Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- R. Install permanent indicators on walls or brackets in accessible and readable positions.
- S. Install connection fittings in accessible locations for attachment to portable indicators.
- T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- U. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic coil in air-handling units.
 - 2. Outside-, return-, supply-, and mixed-air ducts.
- V. Install pressure gages in the following locations:
 - 1. Discharge of each pressure-reducing valve.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Industrial type, liquid in glass type thermometers shall be installed at all the inlets and outlets of each of the following equipment.
 - 1. Air handling unit coils
 - 2. Provide test with EPDM self-sealing rubber inserts
- B. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
 - 1. Liquid-filled or Sealed, bimetallic-actuated type.
 - 2. Direct or Remote-mounted, metal-case, vapor-actuated type.
 - 3. Compact or Industrial-style, liquid-in-glass type.
- C. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.
- B. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

- C. Scale Range for Air Ducts: 0 to 150 deg F.

3.6 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 200 psi.
- B. Scale Range for Condenser-Water Piping: 0 to 150 psi.
- C. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi.
- D. Scale Range for Steam Piping: 0 to 100 psi.

END OF SECTION 230519

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

- B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 3. Design seismic-restraint hangers and supports for piping and equipment.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Pipe stands.
 - 4. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.7 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. B-line, an Eaton business.
 - b. Flex-Strut Inc.
 - c. Thomas & Betts Corporation; A Member of the ABB Group.
 - d. Unistrut; Part of Atkore International.
 - e. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with intumed lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Metallic Coating: Electroplated zinc, Hot-dipped galvanized, Mill galvanized, In-line, hot galvanized, or Mechanically-deposited zinc.
8. Paint Coating: Epoxy or Alkyd.
9. Plastic Coating: PVC or Polyurethane.
10. Combination Coating:

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International.
 - b. ERICO International Corporation.

c. PHD Manufacturing, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Coating: Zinc, Paint or PVC.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Clement Support Services.
 2. ERICO International Corporation.
 3. National Pipe Hanger Corporation.
 4. Pipe Shields Inc.
 5. Piping Technology & Products, Inc.
 6. Rilco Manufacturing Co., Inc.
- B. Insulation-Insert Material for Hot and cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless- steel anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Stainless steel.
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Non-staining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
- C. Flashing;
Metal Flashing: 26gage galvanized steel.
 - 1. Metal Counter-flashing: 22 gage thick galvanized steel.

2. Flexible Flashing: 47 mil thick sheet butyl or other material compatible with roofing. Verify with roofing manufacturer.
 3. Caps: Steel, 22-gage minimum; 16 gage at fire resistant elements.
- D. Sleeves:
1. Ductwork Sleeve 18 gauge Installation and Closure for Fire Rated Walls and Floors: Fire damper assembly with continuous angles on all sides as per NFPA-90A requirements.
 2. Provide and install sleeves for all penetrations in accordance with Division 1.
- E. Escutcheons;
1. Chrome plated cast brass escutcheons with set screws on all exposed piping at wall penetrations in finished spaces.
- F. Hanger Rods:
1. Hanger Rods: Hot rolled steel threaded both ends, threaded one end, or continuous threaded. In accordance with the following schedule.

HANGER ROD SIZE SCHEDULE	
Pipe Size (in)	Min Rod Dia (in)
3/4" to 2"	3/8"
1/2" to 3-1/2"	1/2"
4" to 5"	5/8"
6"	3/4"
8" to 12"	7/8"
14"	1"
16" to 18"	1-1/8"
20"	1-1/4"
24"	1-1/2"
30"	1-7/8"

2. Hanger spacing shall be in accordance with the following schedule for maximum allowable distance. Provide hanger all changes in direction.

PIPE SUPPORT SPACING SCHEDULE		
Pipe Material/ Size (in)	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)
Steel		
Up to 1 1/4"	8	15
1 1/2" to 2 1/2"	10	15
3" and over	12	15
Copper Pipe	8	10
Copper Tubing		
Up to 1 1/4"	6	10
1 1/2" and over	8	10

PVC / HDPE		
Up to 1"	3	10
1 1/4" and over	4	10

3. Fiberglass piping supports spacing shall be in accordance with the manufacture's guidelines.

2.9 VIBRATION ISOLATION HANGERS

- A. Vibration isolation pipe hangers: pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
- F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- H. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- P. Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles on all piping with roller hangers installed outside of insulation. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier not on roller hangers. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply cold galvanizing-repair paint to comply with ASTM A 780. ZRC cold galvanizing compound

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports or metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
7. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
8. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
9. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
10. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
11. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
12. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
13. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
14. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
15. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical type supports and one trapeze member.
 9. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20' or the first two hangers.
- P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- 3.7 MISCELLANEOUS:
- A. Equipment bases and supports.

1. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment. Changers edges all four side. Provide dowels into concrete floor for equipment that is seismically braced.
 2. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment. Provide for all equipment, pumps, air handling units, etc.
 3. Refer to 23 0548 Vibration controls for HVAC piping and piping and equipment for vibration inertia bases.
 4. Construct supports of steel members. Brace and fasten with flanges bolted to structure.
Provide rigid anchors for pipes after vibration isolation components are installed.
- B. Flashing;
1. Provide flexible flashing and metal counter-flashing where piping penetrate weather or waterproofed walls, floors, and roofs.
 2. Flash piping projecting above finished roof surface with prefabricated steel reinforced boot and counter flashing sleeve.
- C. Sleeves;
1. Sleeves are required for all piping passing through walls and/or slabs. Sleeve diameter to be large enough to accommodate insulated piping.
 2. Sleeves through interior non-fire rated walls are to have annular space between pipe and sleeve filled with materials specified in Division 1.
 3. Sleeves thru fire rated walls to have annular space filled with fire stopping wrapping strips and expanding caulking applied with a caulking gun for a minimum depth of 3" or in another manner suitable for the application as recommended by the manufacturer.
See Division 1.
- D. Escutcheons:
1. Provide escutcheons on all wall pipe penetrations that are visible outside MER spaces. All escutcheons shall be chrome plated.

END OF SECTION 230529

SECTION 230553 IDENTIFICATION FOR HVAC PIPING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

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

PART 2 - PRODUCTS

2.1 NAMEPLATES, TAGS, MARKERS, ETC

- A. Manufacturer: W.H. Brady Co., Signmark Div
- B. Acceptable manufacturers offering equivalent products

1. Atlantic Engraving Company.
2. Seton Name Plate Co.
3. MSI Services
4. Substitutions as per Contract Requirements.

C. Description: Nameplates should be as specified in Division 1.

2.3 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass 0.032-inch, stainless steel 0.025-inch, aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black Blue Red White Yellow. As per ANSI depending on service
3. Background Color: Black Blue Red White Yellow as per ANSI depending on service
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black Blue Red White Yellow as per ANSI depending on service
3. Background Color: Black Blue Red White Yellow ANSI depending on service
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the

Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.4 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Black.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.5 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
- E. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
- F. Lettering Size: At least 1-1/2 inches high.

2.6 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
 - 1. Stencil Paint: Exterior, gloss, black unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 2. Identification Paint: Exterior, enamel in colors according to ASME A13.1 unless otherwise indicated.
 - 3. Use on uninsulated pipe or bare painted pipe only.

2.7 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
- C. All new mechanical valves shall be tagged.

2.8 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches minimum.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants

3.2 PIPE LABEL INSTALLATION

- A. Painting of Pipe: all piping that does not receive insulation shall be painted with rust inhibiting machine enamel.
 - 1. Clean piping in accordance with paint manufactures recommendations. Remove all grease oil and surface rust before painting.

2. All Fuel oil piping shall be painted yellow with black labels and flow arrow.
 3. All new and existing gas piping shall be painted yellow with black labels.
 4. Label piping as per ANSI color code
- B. Locate pipe labels where piping is exposed and above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 25' along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- C. Directional Flow Arrows: provide directional flow arrows spaced at maximum intervals of 25' along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.
- D. All Plumbing piping including above ground storm and sanitary, domestic hot and cold-water hot water recirculation, fuel oil and gas shall be labeled. Background color and service name shall be in accordance with ANSI and industry standards.
- E. Lettering shall be no less than 1" on small piping and 2" on piping 3" and larger.

3.3 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in all plumbing piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. All new HVAC valves shall be tagged. All existing HVAC valves that are to remain in the Mer shall be retagged in sequence with new valves. This includes gas fuel oil and domestic water piping systems.

3.4 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

3.5 INSTALLATION

- A. Install tags, markers, etc. in conformance with Division 1.
- B. Unless otherwise specified, color shall conform with ANSI/ASME A13.1

- C. Install identifying devices after completion of coverings and painting.
- D. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.
- E. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished cloth covering, apply paint primer before applying labels.
- F. Install tags using corrosion resistant chain. Number tags consecutively by location.
- G. Apply stencil painting only to bare or painted pipe. Do not apply stencils to insulated pipe.
- H. Identify all equipment, including pumps, air handlers, air cooled condensers, boilers, chillers, pumps, packaged AC units, and hot water heater with nameplates. Small devices, such as in-line pumps, may be identified with metal tags. Identify service of all air handling units, ac units split and packaged units. I.E. Ground floor offices.
- I. Identify control panels and major control components outside panels with nameplates.
- J. Identify valves in main and branch piping with brass tags. Main shutoff valves for boilers shall be furnished with special wording as required by ASME IV HG 710.5 "Supply or Return Valve No. X - Do Not Close Without Also Closing Supply or Return Valve No. Y".
- K. Tag automatic controls, instruments, and relays. Key to control schematic.
- L. Identify piping, concealed or exposed, with markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. 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. Labeling shall be in conformance with OSHA and ANSI A13.1.
- M. Identify all ductwork every 20' with flow arrows and unit or air handler served as well as service, such as SUPPLY AIR, RETURN AIR, EXHAUST AIR. Etc
- N. All smoke purge system components (including supply and exhaust ductwork) shall be clearly identified as such by stenciling the function and zone on the components, e.g., Smoke Purge Supply - Zone 2; Smoke Purge Exhaust - Zone 3; Smoke Damper No. 5; etc. Stenciling shall be 6" high red letters located (every 10 feet along duct).

- O. Identify all Smoke Dampers and Fire Dampers. All dampers shall be sequentially numbered by floor. For example fire damper - FD-1-1 (Fire damper #1, floor 1) Tag shall be 1" high red letters located on damper. Provide red dot stencil on ceiling below damper.
- P. Provide permanent labels for all controls and limits which state function of each control and control set-points.
- Q. Provide tags for the following: new and on re-piped existing equipment including but not limited to the following:
 - Steam systems
 - Natural Gas
 - Condensate

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
- 2. Testing, Adjusting, and Balancing Equipment:
 - a. Motors.
 - b. Packaged roof top units
 - c. Dedicated outside air units
- 3. Testing, adjusting, and balancing existing systems and equipment.
- 4. Control system verification.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the engineer, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Certified TAB reports.
- D. Sample report forms.
- E. Instrument calibration reports, to include the following:
 1. Instrument type and make.
 2. Serial number.
 3. Application.
 4. Dates of use.
 5. Dates of calibration.

1.7 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC NEBB or TABB.
 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB or TABB.
 2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1.8 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. 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.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine operating safety interlocks and controls on HVAC equipment.
- O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental

Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR ALL SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."
- M. Code requirements.

Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the Mechanical Code. Discharge dampers used for air-system balancing are prohibited on constant-volume fans and variable volume fans with motors 10 hp and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power greater than 1 hp, fan speed shall be adjusted to meet design flow conditions.

Therefore, all fans greater than 1 hp shall be provided with variable frequency drives for speed control.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 4. Obtain approval from engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
 - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 - 2. Re-measure and confirm that total airflow is within design.
 - 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
 - 4. Mark all final settings.
 - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 - 6. Measure and record all operating data.
 - 7. Record final fan-performance data.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Adjust the variable-air-volume systems as follows:
 - 1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
 - 2. Verify that the system is under static pressure control.
 - 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.

- e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
- 5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- 6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
- 7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
- 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
- 9. Verify final system conditions as follows:

- a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
- b. Re-measure and confirm that total airflow is within design.
- c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
- d. Mark final settings.
- e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
- f. Verify tracking between supply and return fans.

3.7 PROCEDURES FOR STEAM SYSTEMS

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

3.8 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each steam coil:
 1. Dry-bulb temperature of entering and leaving air.
 2. Airflow.
 3. Inlet steam pressure.
- B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.10 DUCT LEAKAGE TESTS

- A. All Ducts shall be sealed in accordance with specifications Section 23 31 13 Metal Ducts. All duct systems designed to operate at static pressures in excess of 3 inches w.g. or ductwork that is part of a life safety system, including smoke control, smoke purge, stair pressurization and all ductwork that is located outdoor shall be leak tested in accordance with the procedures given *SMACNA HVAC Air Duct Leakage Test Manual*.

Leakage and Seal Classification Table					
System operating pressure in wc			<2" low	2"≥med<3"	High≥3"
Seal Class			C	B	A
Sealing			Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor - Rectangular me			24	12	4
Leakage class CL factor - round metal			12	6	3

- B. Air leakage rates must (CL) less than or equal to 4.0 as determined in accordance with Equations below
1. $CL = F/P^{0.65}$ where:
 2. F -The measured leakage rate in cfm per 100 square feet of duct surface.
 3. P -The static pressure of the test.
- C. Documentation shall be furnished by the test and balancing contractor demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.
- D. Perform duct pressure testing in coordination with Installer.
- E. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- F. Report; submit a report indicating which ductwork sections were tested. Provide single line or double line duct submittal drawing. The drawing shall indicate all systems in their entirety to 3/8' =1'-0" scale. Sections that air leakage tested shall be clearly indicated.
- G. The report shall include full test procedure including how the ductwork was isolated for pressure testing, the pressure of the test and the duration of the test.

- H. Submit duct pressure test procedures used for this project.
- I. Submit summary of test results on a section by section basis, to include all CL, F,P and time.
- J. Witness the duct pressure testing performed by Installer.
- K. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- L. Report deficiencies observed.

3.11 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Verify temperature control system is operating within the design limitations.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 - 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.12 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent.
 - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
 - 4. Cooling-Water Flow Rate: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.13 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for

systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

- B. Status Reports: Prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.14 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

- 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
- 2. Include a list of instruments used for procedures, along with proof of calibration.
- 3. Certify validity and accuracy of field data.

- B. Final Report Contents: In addition to certified field-report data, include the following:

- 1. Pump curves.
- 2. Fan curves.
- 3. Manufacturers' test data.
- 4. Field test reports prepared by system and equipment installers.
- 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

- C. General Report Data: In addition to form titles and entries, include the following data:

- 1. Title page.
- 2. Name and address of the TAB specialist.
- 3. Project name.
- 4. Project location.
- 5. Architect's name and address.
- 6. Engineer's name and address.
- 7. Contractor's name and address.
- 8. Report date.
- 9. Signature of TAB supervisor who certifies the report.
- 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
- 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
- 12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Packaged RTU and Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Motor Data:
 - a. Motor 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. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm.
- b. Total system static pressure in inches wg.
- c. Fan rpm.
- d. Discharge static pressure in inches wg.
- e. Filter static-pressure differential in inches wg.
- f. Preheat-coil static-pressure differential in inches wg.
- g. Cooling-coil static-pressure differential in inches wg.
- h. Heating-coil static-pressure differential in inches wg.
- i. Outdoor airflow in cfm.
- j. Return airflow in cfm.
- k. Outdoor-air damper position.
- l. Return-air damper position.
- m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

- a. System identification.
- b. Location.
- c. Coil type.
- d. Number of rows.
- e. Fin spacing in fins per inch o.c.
- f. Make and model number.
- g. Face area in sq. ft..
- h. Tube size in NPS.
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Average face velocity in fpm.
- c. Air pressure drop in inches wg.
- d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
- e. Return-air, wet- and dry-bulb temperatures in deg F.
- f. Entering-air, wet- and dry-bulb temperatures in deg F.
- g. Leaving-air, wet- and dry-bulb temperatures in deg F.
- h. Water flow rate in gpm.
- i. Water pressure differential in feet of head or psig.
- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.
- l. Refrigerant expansion valve and refrigerant types.
- m. Refrigerant suction pressure in psig.

- n. Refrigerant suction temperature in deg F.
 - o. Inlet steam pressure in psig.
- G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
 - 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.
 - d. Capacity in Btu/h.
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in cfm.
 - i. Face area in sq. ft..
 - j. Minimum face velocity in fpm.
 - 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h.
 - b. Airflow rate in cfm.
 - c. Air velocity in fpm.
 - d. Entering-air temperature in deg F.
 - e. Leaving-air temperature in deg F.
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 2. Motor Data:
 - a. Motor 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. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- J. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.

- f. Final velocity in fpm.
 - g. Space temperature in deg F.
- K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- L. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.15 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.
- B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

F. Prepare test and inspection reports.

3.16 ADDITIONAL TESTS

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

END OF SECTION 230593

SECTION 230713 HVAC DUCTWORK INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Ductwork insulation.
- B. Duct Liner.
- C. Insulation jackets.

1.02 RELATED SECTIONS

- A. Section 23 05 53 - Identification for HVAC Piping and Equipment.
- B. Section 23 31 13 - Ductwork.

1.03 REFERENCES

- A. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- D. NAIMA National Insulation Standards.
- E. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- F. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- H. ASHRAE 90-75 – Insulation Standards

1.04 SUBMITTALS

- A. Division 1 - Submittals: Procedures for submittals.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Submit manufacturers' insulation instructions under provisions of Division 1.

1.05 QUALITY ASSURANCE

- A. Applicator Qualifications: Company specializing in performing the work of this section with minimum three years' experience approved by manufacturer.

1.06 REGULATORY REQUIREMENTS

- A. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with NFPA 255.
- B. Insulation thickness shall comply with all applicable energy conservation codes.

1.07 ENVIRONMENTAL REQUIREMENTS

- 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

2.01 ACCEPTABLE MANUFACTURERS - INSULATION

- A. Owen Corning Fiberglass Corp.
- B. Manville Industrial Products
- C. Certain Teed Corporation
- D. 3M Corporation "Firemaster" for Kitchen Exhaust
- E. Substitutions: Under provisions of Division 1.

2.02 GLASS FIBER, RIGID

- A. Type A: Flexible glass fiber duct insulation; ANSI/ASTM C612; commercial grade; "K" value of 0.25 at 75° F; minimum density of 1-1/2 pounds per cu. ft.; factory applied vapor barrier jacket of 0.7 mil minimum aluminum foil laminated to glass fiber reinforced Kraft paper. Similar to Owens-Corning type FRK-25-ED Type 150 commercial grade.
- B. Type B: Rigid glass fiber board insulation with resin binder; ANSI/ASTM C612, Class 1; "K" value of 0.23 at 75° F minimum density of 6 pounds per cu. ft; factory applied white Kraft faced flame retardant vapor barrier jacket of aluminum laminated to heavy Kraft paper with a flame retardant snuffer type adhesive and reinforced with glass fibers; permeability of 0.2. Similar to Owens-Corning type 705 with AST jacket.

- C. Type C: Molded block or board insulation made of asbestos free hydrous calcium silicate; "K" value of 0.42 at 200° F; minimum density of 14 pounds per cubic foot; temperature range up to 1200° F.
- D. Type D: Flexible Glass Duct Liner: (For standard applications)

ANSI/ASTM C553; "K" value of 0.23 at 75° F; minimum density of 1.5 pounds per cu. ft.; surface finish of black pigmented fire-resistant resilient mastic coated on air side for maximum velocity of 4000 feet per minute.
 - a. Maximum Thermal Conductivity
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - b. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - c. Solvent Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
- E Type "E" – Fire resistant duct wrap consisting of light weight, non-asbestos high temperature non-organic ceramic fiber blanket encapsulated in foil/scrim having a service temperature rating of 2300° F. Wrap shall be applied in two temperature layers to provide a two-hour rated enclosure assembly. Bonding material shall be 304 stainless steel, 3/4" wide and .015" thick.
- G Adhesives: Waterproof fire-retardant type. Smoke and flame spread rating less than 50.
- H. Indoor Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq. yd unless otherwise specified above.
- I. Outdoor Jackets: All exterior ductwork shall be jacketed as per the specification and jacket with Alumaguard Cool Wrap by Polyguard. For watertight insulation jacket install as per manufacturers recommendations. Furnish all mastics and adhesives as per manufacture system.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Install insulation materials only after ductwork has been sealed, tested and approved.
- B. All insulated surfaces are to be cleaned and dried of any foreign material. This includes but is not limited to oil, water, dirt, rust and scale. Completely cover the entire surface to present a tight, smooth appearance.

3.02 INSTALLATION

- A. Division 1 - Quality Control: Install materials in accordance with manufacturer's instructions, specification requirements and in compliance with local code
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Apply insulation in such a way as to permit expansion and/or contraction of metal without causing damage to insulation, joints, seams or finish.
- D. Do not apply additional coats of mastic, adhesive, or sealers until previous coats have thoroughly dried.
- E. Fill in all surface imperfections such as chipped edges, small joints, cracks, holes and small voids with materials o match insulation. Make smooth with a skim coat of insulation cement. Extend surface finish to protect all surfaces and leave no exposed edges.
- F. Provide flashing for insulation installed outdoors to enclose all exposed edges or ends.
- G. Repair existing insulation where damaged by new work. Use materials to match existing.
- H. Cut, score or miter insulation to fit the slope and contour of surface to be covered. Insulation up to 3 inches thick to be applied in single layer. Over 3 inches apply in multiple layers, with joints staggered.

3.03 HVAC DUCT INSULATION SCHEDULE

Service Thickness	Type	Insulation
¹ Interior H&V, AC systems; SA, RA & EA, ductwork that is exposed in equip rooms.	B	1-1/2"
¹ Interior H&V, AC systems; SA, RA & EA including flexible run outs, that is concealed.	A	2"
Outside air intake ductwork All	B	1 1/2"
² Exterior H&V, AC systems; SA, RA & RA, ductwork that that is exposed outdoors.	B	2"
Acoustically line all SA & RA ductwork For a distance of 20' from fan inlet and outlet and 10' downstream of all VAV boxes.	D	1/2"
⁵ Interior exposed H&V, AC systems; SA, RA located in conditioned spaces rectangular, spiral round or oval ductwork;		

Located in conditioned space	D	1 "
Located in unconditioned space, plenum or equipment room.	D	1 1/2"
⁴ Smoke purge exhaust and supply	E	2"
All Stair pressure ductwork	E	2"
Generator exhaust pipe and muffler	C	2"
Kitchen hood exhaust (grease duct) (2) 1" layers.	E	2" applied in
1. Reduce external insulation to 1" for internally lined ductwork except for outdoor installations. On outdoor installations insulation thickness shall be as scheduled but not less than the height of standing seams or angle bracing.		
2. Insulation Thickness shall be no less than the size indicated or the height of standing seams or angle bracing.		
3. Outside air intake and Kitchen exhaust ducts shall not be internally lined.		
4. Smoke purge system supply and exhaust ducts passing through a rated Exit-way or within a fire-rated suspended ceiling assembly and all Kitchen Hood exhaust ducts shall be wrapped with thermal fiber - two (2) hour or encased in a two (2) hour rated enclosure. Trapeze hangers to be outside of thermal wrapping.		
5. All square or rectangular ductwork that is exposed to view in finished spaces shall be internally insulated.		
6. All exterior ductwork shall be insulated and jacketed.		

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Piping insulation
- B. Jackets and accessories

1.02 RELATED SECTIONS

- A. Section 23 05 53 – Identification for HVAC Piping and Equipment.
- B. Section 23 21 13 - Hydronic Piping.

1.03 REFERENCES

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
- C. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
- D. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and 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 C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation
- G. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.
- H. ASTM C578 - Standard Specification for Preformed, Cellular Polystyrene Thermal Insulation
- I. ASTM C610 - Standard Specification for Expanded Perlite Block and Pipe Thermal Insulation
- J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
- K. NAIMA National Insulation Standards
- L. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials

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

N. ASHRAE 90-75 - Insulation Standards

1.04 SUBMITTALS FOR REVIEW

A. Division 1 – Submittal Requirements.

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

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

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years' experience.

1.06 REGULATORY REQUIREMENTS

A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with NFPA 255

B. Insulation thickness shall comply with applicable Energy Conservation Codes.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Pittsburgh Corning Corporation

B. Certainteed Corporation.

C. Armstrong Corporation.

D. Manville Industrial Products.

E. Owens-Corning Fiberglass Corporation

F. Polyguard

2.02 INSULATION

A. Type A: Molded glass fiber insulation; ANSI/ASTM C547; 'k' value of 0.23 at 75° F; noncombustible. Minimum density of 3.5 lbs./cu. Ft.; temperature range 35° F to 450° F.

- B. Type B: Cellular glass insulation; ASTM C552; 'K' Value of 0.53 at 75°F; non-combustible. Minimum density of 8.0 lbs./cu. ft. similar to Pittsburgh Corning Foamglas.
- C. Type C: Elastomeric insulation; ASTM C518, C177; 'K' Value of 0.27 at 75°F; non-combustible. Similar to Armstrong "AP Armaflex"; temperature range -40° F to 220° F
- D. Type D; Underground engineered pipe insulation system shall be as follows;
Service pipe insulation shall be spray applied .16k-factor, R141B blowing agent, nominal 2 pound per cubic foot density, polyurethane foam for straight sections and preformed polyurethane foam for all fittings. Insulation shall not be less than 2" and shall be Perma-pipe polytherm

2.03 JACKETS

A. Interior Applications:

- 1. Insulation Type A - Factory applied, white, flame retardant, all service (ASJ) vapor barrier jacket of .001" aluminum foil laminated to Kraft paper with a flame retardant snuffer type adhesive reinforced with glass fibers and having a self-sealing lap. Provide 2" longitudinal lap and 4" circumferential sealing strips. Permeability .02 perm.

B. Exterior Applications:

- 1. Insulation Type A thickness as scheduled with ASJ vapor barrier jacket - Cover factory interior jacket with Alumaguard Cool Wrap by Polyguard, rubberized bitumen membrane designed specifically to be installed over insulation on exterior piping, tanks, vessels, and equipment. The membrane shall be 'peel and stick', self-healing if punctured, UV stable, and will expand and contract with the mechanical system. All seams shall be sealed watertight. Permeability .0053 perm

C. Piping exposed in Mechanical Rooms or any space: (not used)

- 1. All exposed piping and fittings shall be completely covered with white Zeston 2000 PVC insulated piping and fitting covers. Apply as per manufacturer with perma weld adhesive.

D. Underground applications: (not used)

All straight sections of the insulated piping system shall be filament wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. The jacket shall be either filament wind fiberglass directly onto the polyurethane foam or injected foam into a fiberglass outer casing. Fiberglass outer casing shall be A.O. Smith Red Thread or Ameron Bondstrand 3000. Thermoplastic casing material that are not rated for temperatures above 140 degrees F will not be allowed, e.g., PVC or HDPE. The minimum thickness for FRP jacket shall be as 0.55"

2.04 ACCESSORIES

- A. Insulation Bands: $\frac{3}{4}$ " wide; 0.007-inch-thick aluminum.
- B. Metal Jacket Bands: $\frac{3}{8}$ " wide; 0.015-inch-thick aluminum.
- C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.
- D. Finishing Cement: ASTM C449
- E. Fibrous Glass Cloth: Untreated; 9 oz/sq. yd weight.
- F. Adhesives: Compatible with insulation and fire retardant.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with all foreign material removed. This includes but is not limited to water, oil, dirt, scale and rust.
- D. Only insulation and finish materials including adhesive cements and mastic which conform to the requirements of all-governing codes and ordinances shall be used.

3.02 INSTALLATION

- A. Division 1 – Quality Control: Install materials in accordance with manufacturer's instructions and the best practice of the trade.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulation on all piping shall be vapor sealed. On insulated piping with vapor barrier, insulate all fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints. Vapor seal all exposed edges with jacket material and vapor barrier type adhesive.
- D. Repair or replace any existing insulation and surface finish disturbed or damaged by installation of new work using materials to match existing.
- E. Apply insulation to completely cover metal surface. Surface shall be applied to present a tight, smooth appearance.
- F. Exposed Piping: Locate insulation and cover seams in least visible locations.

- G. For hot piping conveying fluids 140 degrees F or less, and on insulated piping without vapor barrier, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- H. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- I. Neatly finish insulation at supports, protrusions, and interruptions.
- J. Do not use staples on vapor barrier insulation.
- K. Jackets:
 - 1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with vapor barrier, factory-applied or field-applied. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets may be used
 - 2. Indoor, Concealed Applications: Insulated dual-temperature pipes or pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe, and finish with glass cloth and vapor barrier adhesive.
 - 3. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate and jacket as for concealed applications, and finish with PVC jackets. up to 10' from finished floor.
 - 4.
 - 4. Cover factory interior jacket with Alumaguard Cool Wrap by Polyguard, rubberized bitumen membrane designed specifically to be installed over insulation on exterior piping, tanks, vessels, and equipment. The membrane shall be 'peel and stick', self-healing if punctured, UV stable, and will expand and contract with the mechanical system. All seams shall be sealed watertight. Permeability .0053 perm
- L. Inserts and Shields:
 - 1. Application: All insulated Piping 2 inches diameter or larger shall be installed with inserts and shields as follows.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- M. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.
- N. Underground applications: (NOT USED)

The internal pipe shall be hydrostatically tested to 150 psig or 1½ times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field applied insulation shall be placed only in straight sections. Field insulation of fittings shall not be acceptable. The mold for the polyurethane shall be made of clear adhesive backed polyester film. The installer shall seal the field joint area with a heat shrinkable adhesive backed wrap or with wrappings of glass reinforcement fully saturated with a catalyzed resin identical in properties to the factory-applied resin. Backfilling shall not begin until the heat shrink wrap has cooled or until the FRP lay-up has cured. All insulation and coating materials for making the field joint shall be furnished by the piping system manufacture

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

3.4 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.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

INSULATION SCHEDULE

Refer to the insulation schedule below for pipe insulation thickness by system. Not all systems are necessarily included in this project

INSULATION SCHEDULE							
SERVICE	INSULATION	TEMPERATURE	NOMINAL PIPE SIZE				
	TYPE	RANGE (F°)	<1"	1" to < 1 1/2"	1 1/2" to < 4"	4" to < 8"	≥ 8"
Hot Water (HW)	A		INSULATION THICKNESS				
		> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	1 1/2	1 1/2	2	2	2
		105°-140°	1	1	1 1/2	1 1/2	1 1/2
Buried (HW)	C	> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	2	2	2 1/2	2 1/2	2 1/2
		105°-140°	1 1/2	1 1/2	2	2	2
Chilled Water (CHW)	A	40° - 60°	1/2	1/2	1	1	1
		< 40°	1/2	1	1	1	1
Buried (CHW)	C	40° - 60°	1	1 1/2	1 1/2	1 1/2	1 1/2
		< 40°	1	1 1/2	1 1/2	1 1/2	1 1/2
Steam & Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Steam Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Condensate Drains	A	All	1/2	1/2	1	1	1
Cold Water Make up	A	All	1/2	1/2	1	1	1
Refrigerant Hot Gas	C	All	1 1/2	1 1/2	2	2	2
Humidifier Steam	A	All	2 1/2	2 1/2	2 1/2	3	3
Refrigerant Suction	C	All	1/2	1/2	1	1	1

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 23

1.3 SCOPE

- A. Commissioning requires the participation of Division 23, Mechanical Contractor and Subcontractors, to ensure that all systems are operating in a manner consistent with the Contract Documents.
- B. Commissioning on all HVAC systems listed below shall be a Delegated Design. The mechanical contractor shall include in his bid all cost associated hiring a commissioning agent to execute the scope of work as outlined below.
- C. Submit for review and approval by the engineer a commissioning plan, pre-functional test checklist, functional check lists, and all test results. A report shall be issued at the time of functional testing indicating each piece of equipment, the test performed, the result of each test, and the recommended corrective measure.
- D. Functional tests shall be repeated until all equipment is functioning properly and in accordance with the sequence of operation.
- E. Functional tests must include simulating conditions that will make the automatic temperature controls systems perform all sequences of operation automatically. Example. Simulate pump failure by shutting down the running pump to test automatic pump change over.
- F. Final functional testing shall be performed in the presence of the Engineer.
- G. SYSTEMS TO BE COMMISSIONED
- H. The following Mechanical systems will be commissioned on this project:
 - 1. Mechanical Systems
 - a. Rooftop Units

- b. DOAS units
 - c. Condensing Units
 - d. VRF systems
 - e. Control Dampers and Control Valves
 - f. Automatic Controls
- 2. Spot checking of air balancing readings including total building space pressurization.
- 3. All Direct Digital Controls (DDC) shall be verified for proper operation as it relates to the above equipment including interfaces for remote monitoring.
- 4. Fire Alarm System: Verification of the fire alarm system as it interfaces with the HVAC system such as duct smoke detectors and fire/smoke dampers shall be verified.

1.4 RESPONSIBILITIES

- A. Commissioning responsibilities applicable to the Mechanical contractor of Division 23.

1.5 OPERATION AND MAINTENANCE (O&M) MANUALS

- A. Compile and prepare documentation for all equipment and systems covered in Division 23, Mechanical, and deliver to Construction Manager for inclusion in O&M Manuals in accordance with Division 1.
- B. Provide the Commissioning Agent with a copy of O&M Manuals for review.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Provide test equipment necessary to fulfill testing requirements of Division 23, Mechanical.

PART 3 - EXECUTION

3.1 PREFUNCTIONAL CHECKLISTS AND STARTUP

- A. Pre-functional tests and checklists (PFT's) are important to ensure that the equipment and systems are connected properly and are operational. PFT's ensure that functional performance testing may proceed without unnecessary delays. The Contractor shall be responsible for performing Pre-functional testing. EVERY piece of equipment to be commissioned receives a full Pre-functional checkout.
- B. Division 23, Mechanical contractor, has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting design objectives of Contract Documents. Commissioning procedures and functional testing do not relieve or lessen this responsibility for deficiency resolution or shift that responsibility partially to Engineer or Owner.

3.2 FUNCTIONAL PERFORMANCE TESTS

- A. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to completion of systems or sub-systems at discretion of commissioning agent and the engineer. Beginning system testing before full completion does not relieve Contractor from fully completing system as soon as possible, including pre-functional checklists. Refer
- B. Functional performance testing requirements are in addition to and do not replace any testing required by Code or listed elsewhere in Division 23.
- C. Functional performance testing procedures will be performed on but not be limited to the following system types and equipment. Final functional testing requirements and procedures will be developed based on approved equipment shop drawings.
 - 1. Mechanical Systems
 - a. Rooftop Units
 - b. Rooftop ERVs
 - c. DOAS units
 - d. Condensers
 - e. VRF systems
 - f. Control Dampers and Control Valves
 - g. Automatic Controls

3.3 ISSUES AND DEFICIENCIES

- A. All deficiencies shall be detailed in functional testing report and or log. The report shall also include the corrective measures required and resolution of issues and deficiencies.

3.4 TRAINING OF OWNER PERSONNEL

- A. Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.
- B. Duration of Training: Mechanical Contractor shall provide training on each piece of equipment. Allow as least (2) separate 4-hour sessions. .

END OF SECTION 230800

SECTION 230901 – DIRECT DIGITAL CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. These basic Mechanical Requirements apply to all Division 23 Sections.
- B. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all mechanical for this project, as required by the contract documents.

1.2 Qualifications of Bidder

- A. All bidders must be building automation contractors in the business of installing direct digital control building automation systems for a minimum of 5 years.
- B. All bidders must have a service and installation office in the Westchester area.
- C. All bidders must be authorized distributors or branch offices of the manufacturers specified.
- D. All bidders must have a trained staff of application engineers, who have been certified by the manufacturer in the configuration, programming and service of the automation system.
- E. Manufacturers: Basis of design shall be Andover Controls Corporation by Schneider Electric. Other manufacturers must be compatible with the existing BMS system.

1.3 Scope of Work

- A. Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, software, sensors, transducers, relays, valves, dampers, valve and damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Unless otherwise specified, provide operators for equipment such as dampers and valves if the equipment manufacturer does not provide these. Coordinate requirements with the mechanical contractors.
- B. The Building Automation System (BAS) contractor shall review and study all HVAC drawings and the entire specification to familiarize himself with the equipment and system operation, and to verify the quantities and types of dampers, operators, alarms, controllers etc. to be provided. Review the existing temperature controls equipment installed in the building. ALL NEW TEMPERATURE CONTROLS EQUIPMENT SHALL BE ANDOVER CONTINUUM SERIES VERSION 1.9. OR LATER.
- C. All interlocking, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor and representatives of the Owner will review and check out the system. At that time, the BAS contractor shall demonstrate

the operation of the system and prove that it complies with the intent of the drawings and specifications.

- D. The Contractor shall furnish and install a complete building automation system including all necessary hardware, network wiring, all operating applications software, and all programming necessary to perform the control sequences of operation as called for in the specifications. The scope of work shall include control over, and graphic representation all new mechanical equipment installed as part of this project.
- E. At a minimum, provide controls for the following:
 - 1. New packaged Rooftop units
 - 2. All new VAV boxes
 - 3. VRF split systems
 - 4. Dedicated outdoor air systems (DOAS)
- F. New packaged roof top units, DOAS, and VRF split systems shall be supplied with the manufactures operating controller. Provide BACnet interface with all new equipment as required provide scheduling and reset functions and as well as the sequence of operations for all equipment as given in this section or in specification sections.
- G. Provide services and manpower necessary for commissioning of system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.
- H. All work performed under this section of the specifications will comply with all codes, laws and governing bodies. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.
- I. Provide all labor and materials to perform all programming necessary at the owners existing operator workstation located in the HS/MS complex. Graphically represent and control each and every piece of equipment in the lists above all input and output status points, and functional points.

1.4 System Description

- A. The Building Automation System (BAS) shall consist of PC-based workstation and microcomputer controllers of modular design providing distributed processing capability and allowing future expansion of both input/output points and processing/control functions. For this project the system shall consist of the following components:

- B. Operator Workstations. (Not in Scope)

The BAS Contractor shall furnish (1) Operator Workstation Computer and (1) printer as described in Part 2 of the specification. This workstation must be running the standard workstation software developed and tested by the manufacturer of the network controllers and the standalone controllers. No third-party front-end workstation software will be acceptable. Provide all necessary software and licensing as required

- C. Ethernet-based Network Controllers.

1. The BAS Contractor shall furnish Ethernet-based network controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet, provide communication to the Standalone Digital Control Units and/or other Input/Output Modules and serve as a gateway to equipment furnished by others (if applicable).
- D. Standalone Digital Control Units (SDCUs).
 1. Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment.
- E. Service Tool. (Not in Scope)
 1. Provide a portable service tool for monitoring and commissioning of the network and Standalone Digital Control Units. The tool shall have all the appropriate software for system access and have the same functionality as the main work station.
- F. Modem. (Not in Scope)
 1. A modem shall be furnished for remote interrogation of the system. The modem shall operate at a minimum of 28.8 KBaud and allow for access to the entire network of controllers.
- 1.5 Work by Others
 - A. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.
 - B. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.
 - C. The BAS Contractor shall provide field supervision to the designated contractor for the installation of the following as required:
 1. Automatic control dampers
 2. Fire/smoke dampers
 3. Sheet metal baffle plates to eliminate stratification.
 - D. The Electrical Contractor shall provide:
 1. All 120v power wiring to motors, heat trace, junction boxes for power to BAS panels.
 2. Smoke detectors. HVAC Contractor to mount devices. BAS Contractor to hardwire to fan shut down. BAS contractor to coordinate this with the electrical contractor.

E. The BAS Contractor shall provide:

1. BAS Contractor to hardwire to fan shut down. BAS contractor to coordinate this with the electrical contractor.

1.6 Code Compliance

- A. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.
- B. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.
- C. All wiring shall conform to the National Electrical Code.
- D. All smoke dampers shall be rated in accordance with UL 555S.
- E. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
- F. Comply with FCC, Part 68 rules for telephone modems and data sets.

1.7 Submittals

- A. The Contractor shall furnish all submittals in PDF format. Drawings shall be B size or larger.
- B. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical will be allowed where appropriate.
- C. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.
- D. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. All literature, descriptions, equipment spec sheets, sequences etc shall be on 8 1/2 x 11 or larger sized sheets. All details diagrams and schematics shall be on 11X17 sized sheets or larger.
- E. Submit shop drawings to the Engineer for review and approval prior to ordering or fabrication of the equipment. The Contractor prior to submitting shall check all documents for accuracy.
- F. The Engineer will make corrections and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. No controls submittals shall

approved until all controls have fully coordinated with equipment manufactures requirements.

- G. Submit a training class syllabus and training manual for review with the temperature controls submittal. The training manual shall be custom made for this project. Manufactures brochures, and installation manuals will not be acceptable for this purpose. Submit a type written overview and a written summary of each topic to be covered. The document shall be suitable for a system operator to use as a quick reference guide to basic system operation as applicable for this project. Refer to section 1.9 paragraph B, for the minimum requirement of training to be included.

1.8 System Startup & Commissioning

- A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
- B. The BAS contractor shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives.
- C. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing of the systems. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

1.9 Training

- A. The BAS Contractor shall provide both on-site training to the Owner's representative and maintenance personnel per the following description:
- B. On-site training shall consist of a minimum of (2) separate 2-hour sessions of hands-on instruction geared at the operation and maintenance of the systems. The sessions shall be scheduled at the beginning of substantial completion and spaced out over the first year of owner use. The first session curriculum shall include
 - 1. System Overview
 - 2. System Software and Operation
 - a. System access
 - b. Software features overview
 - c. Changing set-points and other attributes
 - d. Scheduling
 - e. Editing programmed variables
 - f. Displaying color graphics

- g. Running reports
 - h. Workstation maintenance
 - i. Application programming
 - 3. Operational sequences including start-up, shutdown, adjusting and changing system variables. These items shall be reviewed for all equipment installed under this project and or connected to the BMS under this project.
 - 4. Equipment and hardware overview and maintenance. This shall include:
 - a. Review of all hardware installed under this project
 - b. Review of a system schematic.
 - c. Review of where each controller is located in the building and what its function is. This shall include a walking, hands-on tour and demonstration of each and every controller.
- 1.10 Operating and Maintenance Manuals
- A. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the lead-time and expected frequency of use of each part clearly identified.
 - B. Following project completion and testing, the BAS contractor will submit as-built drawings reflecting the exact installation of the system. The as-built documentation shall also include a copy of all application software both in written form and on diskette.
- 1.11 Warranty
- A. The BAS contractor shall warrant the system for 12 months after system acceptance and beneficial use by the owner. During the warranty period, the BAS contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the Sequence of Operation section of the specification.
 - B. Updates to the manufacturer's software shall be provided at no charge during the warranty period.
- 1.12 Programming
- A. Sequence of operations: The controls contractor shall review the sequences of operation given in section 23 09 93 of this specification. "Canned", preprogrammed, or typical sequences by the manufacture may not be acceptable and shall only be used if accepted by the engineer. Otherwise, the controls contractor shall be capable of and responsible for providing custom programming, hardware, software, and labor as required to achieve the sequences of operation as specified.

PART 2 - SYSTEM ARCHITECTURE

2.1 General

- A. The Building Automation System (BAS) shall consist of all new Network Control Units (NCUs), a family of Standalone Digital Control Units (SDCUs), Input/Output Unit Modules (IOU Modules), Operator Workstations (OWs), and one File Server to support system configurations where more than one operator workstation is required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire classroom building and all new and existing equipment in the building, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database
- B. Level 1 Network Description
- C. Level 1, the main backbone of the system, shall be an Ethernet LAN/WAN. Network Control Units, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices. The contractor shall visit the site and review the existing Andover temperature controls equipment installed in the building and in the physical plant. Certain of these controllers may be suitable for reuse. The network shall be an extension of the existing in the building as required to achieve a complete system,
- D. Level 2 Network Description
- E. Level 2 of the system shall consist of one or more field buses managed by the Network Control Units. The Level 2 field buses may consist of one or both of the following types:
- F. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or
- G. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules.
- H. These IOU modules may be mounted within the NCU enclosure or remotely mounted via a single, twisted, shielded pair of wires.
- I. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.
- J. Standard Network Support
- K. All NCUs, Workstation(s) and File Server shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NCU's, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an

existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

- L. Remote Communications
- M. In addition to the above LAN/WAN architecture support, the same workstation software (front end) must be capable of managing remote systems via standard dial-up phone lines as a standard component of the software. Front-end "add-on" software modules to perform remote site communication shall not be acceptable.
- N. The remote system architecture shall consist of two levels providing control, alarm detection, reporting and information management for the remote facility. Level 1 shall contain the Remote Site Control Unit, communicating to the remotely located, Operator Workstation(s) through the use of a modem and a standard dial-up phone line. Level 2 shall consist of one or more field buses controlled by the RSCU. The field buses may consist of one or both of two types:
 - O. 1) An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or
 - P. 2) An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules that may be mounted within the RSCU enclosure or remotely mounted on a single, twisted, shielded pair of wires.
- Q. System Expansion
- R. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
- S. The BAS shall be expandable to include Security and Access Control functions at any time in the future with no additional workstations, front-end software or Level 1 controllers required. Standalone Digital Control Units or IOU modules shall be able to be added to the existing Level 1 controller's field bus(es), to perform security and card access applications. In this way, an owner's existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized.
- T. Additionally, an integrated video badging option must be able to be included with no additional workstations required. This photo ID option must share the same database as the BAS in order to eliminate the need for updating multiple databases.
- U. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

V. Support For Open Systems Protocols

The BAS design must include solutions for the integration of the following “open systems” protocols: BACnet, LonTalk™, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).

- W. The system shall also provide the ability to program custom ASCII communication drivers, that will reside in the NCU, for communication to third party systems and devices. These drivers will provide real time monitoring and control of the third-party systems.

2.2 Network Control Units (NCUs)

- A. Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of NCUs shall be supplied to fully meet the requirements of this specification and the attached point list. NCUs for telephone dialup sites shall be of the same design as the Ethernet control units but without the plug-in Ethernet network interface card (NIC), i.e., NCUs, which include a NIC, shall be interchangeable whether used on a LAN/WAN or a dialup site.

B. Webserver Functionality

All NCUs on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a Web Server. The NCU shall have the ability to store HTML code and “serve” pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer™, Netscape Navigator™, etc.) to access real-time data from the entire BAS via any NCUs.

Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller, or process or network interface (BACnet, LonTalk and TCP/IP) that the BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

The BAS network controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored on any shared network device. The BAS WEB server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications

1. Memory:
A minimum of 64MB of RAM shall be provided for NCUs with expansion up to 128 MB. The 64 MB versions shall include a floating-point math co-processor.
2. Communication Ports:
Each NCU shall provide communication to both the Workstation(s) and the field buses. In addition, each NCU must have at least 3 other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system the NCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).
3. Input/Output (I/O):
Each NCU shall support the addition of the following types of inputs and outputs:
 - Digital Inputs for status/alarm contacts
 - Counter Inputs for summing pulses from meters.
 - Thermistor inputs for measuring temperatures in space, ducts and thermowells.
 - Analog inputs for pressure, humidity, flow and position measurements.
 - Digital Outputs for on/off equipment control.
 - Analog Outputs for valve and damper position control, and capacity control of primary equipment including all air handler and fan coil control valves
4. Modular Expandability:
The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.
5. Hardware Override Switches:
All digital output units shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition, each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.
6. Local Status Indicator Lamps:
Provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each output, provide LED indication of the value of the output (On/Off). For each output module provide an LED which gives a visual indication of whether any outputs on the module are manually overridden.
7. Real Time Clock (RTC):
Each NCU shall include a battery-backed, real-time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation the system clock will be based on

the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.

8. Power Supply:

The power supply for the NCUs shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (-48 VDC).

9. Automatic Restart After Power Failure:

Upon restoration of power after an outage, the ECU shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

10. Battery backup:

Each NCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe (such as 1 hour) of running on full UPS, the unit will shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software Specifications

1. General.

The NCU shall contain flash ROM as the resident operating system. Application software will be RAM resident. Application software will only be limited by the amount of RAM memory. There will be no restrictions placed on the type of application programs in the system. Each NCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. User Programming Language:

The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The NCU shall have the ability to perform the following pre-tested control algorithms:
 - a. Proportional, Integral plus Derivative Control (PID)
 - b. Self Tuning PID
 - c. Two Position Control
 - d. Digital Filter
 - e. Ratio Calculator
 - f. Equipment Cycling Protection
2. Mathematical Functions:
 - a. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.
3. Energy Management Applications:
 - a. NCUs shall have the ability to perform any or all of the following energy management routines:
 - b. Time of Day Scheduling
 - c. Calendar Based Scheduling
 - d. Holiday Scheduling
 - e. Temporary Schedule Overrides
 - f. Optimal Start
 - g. Optimal Stop
 - h. Night Setback Control
 - i. Enthalpy Switchover (Economizer)
 - j. Peak Demand Limiting
 - k. Temperature Compensated Duty Cycling
 - l. CFM Tracking
 - m. Heating/Cooling Interlock
 - n. Supply air temp Reset
4. History Logging:
 - a. Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

5. Alarm Management:

- a. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the NCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the Operator Workstation is temporarily interrupted, the alarm will be buffered in the NCU. When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition.

6. Reporting.

- a. The NCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

2.3 Standalone Digital Control Units (SDCUs)

A. General:

1. Standalone Digital Control Units shall provide control of HVAC and lighting. Each controller shall have its own control programs and will continue to operate in the event of a failure or communication loss to its associated NCU.

B. Memory:

1. Control programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Communication Ports:

1. SDCUs shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the NCU online. It shall be possible from a service port on any SDCU to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any NCU or any SDCU on a different field bus.

D. Input/Output:

1. Each SDCU shall support the addition of the following types of inputs and outputs:
 - a. Digital Inputs for status/alarm contacts
 - b. Counter Inputs for summing pulses from meters.

- c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
 - d. Analog inputs for pressure, humidity, flow and position measurements.
 - e. Digital Outputs for on/off equipment control.
 - f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.
- E. Expandability:
 - 1. Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two modules shall be added to the base SDCU before additional power is required.
- F. Networking:
 - 1. Each SDCU will be able to exchange information on a peer-to-peer basis with other Standalone Digital Control Units during each field bus scan. Each SDCU shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each SDCU shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to an NCU.
- G. Indicator Lamps:
 - 1. SDCUs will have as a minimum, LED indication of CPU status, and field bus status.
- H. Real Time Clock (RTC):
 - 1. An SDCU shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each SDCU shall receive a signal, every hour, over the network from the NCU which synchronizes all SDCU real time clocks.
- I. Automatic Restart After Power Failure:
 - 1. Upon restoration of power, the SDCU shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.
- J. Battery Back Up:
 - 1. Each SDCU shall have at least 3 years of battery back up to maintain all volatile memory.

K. Alarm Management:

1. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the SDCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered. Alarm messages can be sent to a local terminal or modem connected to an NCU or to the Operator's Workstation(s). Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the NCU is temporarily interrupted, the alarm will be buffered in the SDCU. When communications return, the alarm will be transmitted to the NCU if the point is still in the alarm condition.

L. Air Handler Controllers

1. AHU Controllers shall be capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.
2. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
3. AHU Controllers shall be fully user programmable to allow for modification of the application software.
4. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.
5. A manual override switch shall be provided for all digital and analog outputs on the AHU Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

M. VAV Terminal Unit Controllers

1. VAV Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:
 - a. Single Duct Cooling Only
 - b. Single Duct Cooling with Reheat (Electric or Hot Water)
 - c. Fan Powered (Parallel or Series)
 - d. Dual Duct (Constant or Variable Volume)
 - e. Supply/Exhaust
2. VAV Controllers for single duct applications will come equipped with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb., and contain an override mechanism for manual positioning of the damper during startup and service. VAV Controllers shall contain an integral velocity sensor accurate to +/- 5% of the full range of the box's CFM rating. Each controller shall perform the sequence of operation described in Part 3 of this specification, and have the capability for time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending. VAV Controllers shall be able to communicate with any

other Standalone Digital Control Unit on the same field bus with or without communication to the NCU managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 VAV controllers per field bus.

3. Unitary Controllers

- a. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:
 - 1) Cabinet heater and convectors
 - 2) Rooftop top air handling units
 - 3) Fan Coils
 - 4) Unit and cabinet heaters
- b. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

N. Display Controllers (Not used)

- 1. Display controllers are standalone, touch screen based operator interfaces. The controller shall be designed for flush mounting in a finished space, with a minimum display size of 9 x 9 inches. Software shall be user programmable allowing for custom graphical images that simulate floor plans, menus, equipment schematics along with associated real time point values coming from any NCU on the network. The touch screen display shall contain a minimum of 64 possible touch cells that permit user interaction for changing screens, modifying set-points or operating equipment. Systems that do not offer a display controller as specified must provide a panel mounted computer with touch screen capability as an alternative. All air handling units shall use display controllers.

2.4 Operator Workstation Requirements

- A. The building Andover system has an existing operator workstation that shall be reused.

2.5 Portable Operator's Terminal (NOT USED)

2.6 DDC Sensors and Point Hardware

A. Temperature Sensors

- 1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
- 2. Space sensors shall have off white enclosure and shall be mounted on a standard electrical box. Space sensors shall use surface mounted finished cast

electrical box for surface mounting with metal "wire-mold" to conceal wiring for all solid masonry partitions. For space sensors located on gypsum board partitions, wiring shall be concealed inside the walls with recessed flush mounted electrical boxes. In general, control wiring shall run from the ceiling plenum to the box which shall be wall mounted next to the door or as shown on plan. (This shall be the standard for this project)

3. The space sensor housing shall utilize buttons for adjusting the space temperature set-point, as well as a push button for selecting after hours operation, fan speed and all and other operator selectable parameters. Operators shall be able to adjust set points directly from the sensor. All space sensors, (located in public location, office, classrooms), shall incorporate either an LED or LCD display for viewing the space temperature, set-point and other operator selectable parameters. Space sensors located in store rooms, MER, and unoccupied space are not required have LED or LCD display.
4. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
5. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
6. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
7. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Sensors

1. Humidity devices shall be accurate to +/- 5% at full scale for space and +/- 3% for duct and outside air applications. Suppliers shall be able to demonstrate that accuracy is NIST traceable.
2. Provide a handheld field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

C. Pressure Sensors

1. Air pressure measurements in the range of 0 to 10" water column will be accurate to +/- 1% using a solid-state sensing element. Acceptable manufacturers include Modus Instruments and Mamac.
2. Differential pressure measurements of liquids or gases shall be accurate to +/- 0.5% of range. The housing shall be Nema 4 rated.

D. Current and KW Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core

models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.

2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

E. Flow Sensors

1. Provide an insertion vortex flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by EMCO or approved equal.

F. Electric/Pneumatic Transducers

1. Electric to pneumatic transducers shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0 - 20 psi operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.
2. E/P transducers may be installed at the end device (damper or valve), or mounted separately in a field interface panel, or as part of the controller. All transducers will be calibrated. Panel mounted transducers shall be Sensycon or approved equal.

G. Electric/Pneumatic Solenoid Valves

Electric solenoid operated pneumatic valves (EP's) shall have a three-port operation: common, normally open and normally closed. They shall be rated for 50 psig when used for 25 psig or less applications, or rated for 150 psig when used for 100 psig or less applications. The coils shall be equipped with transient suppression devices to limit transients to 150 percent of the rated coil voltage.

2.7 Control Valves

- A. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
- B. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
- C. Trim material shall be stainless steel for steam and high differential pressure applications.
- D. Electric actuation should be provided on all terminal unit reheat applications.

2.8 Dampers

- A. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.
- B. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals, and acetal or bronze bearings shall also be provided.
- C. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.
- D. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.
- E. Control and smoke dampers shall be Ruskin, or approved equal.
- F. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

2.9 Damper Actuators

- A. Electronic Actuators – the actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

2.10 Smoke Detectors

- A. Air duct smoke detectors shall be by Air Products & Controls or approved equal. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.
- B. The smoke detector shall utilize a photoelectric detector head.
- C. The housing shall permit mechanical installation without removal of the detector cover.
- D. The detectors shall be listed by Underwriters Laboratories and meet the requirements of UL 268A.

2.11 Airflow Measuring Stations

- A. Provide a thermal anemometer using instrument grade self-heated thermistor sensors with thermistor temperature sensors.

- B. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.
- C. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.
- D. Furnish Ebtron Series 3000 airflow stations or approved equal.

PART 3 - EXECUTION

3.1 Contractor Responsibilities

A. General

Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

B. Demolition

- 1. Remove controls which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing and or wiring. The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner. All other equipment which is removed will be disposed of by the Contractor.

C. Access to Site

- 1. Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner's Representative.

D. Code Compliance

- 1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in Division 17 and Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

E. Cleanup

- 1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

3.2 Wiring, Conduit, and Cable

- A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt

Class Three	18 Gauge Std.	300 volt
Communications	Per Mfr.	Per Mfr.

- B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.
 - C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
 - D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
 - E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
 - F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.
 - G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.
 - H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.
 - I. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.
 - J. Only glass fiber is acceptable, no plastic.
 - K. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.
 - L. Hardware Installation
- 3.3 Installation Practices for Wiring
- A. All controllers are to be mounted vertically and per the manufacturer's installation documentation.

- B. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.
- C. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
- D. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.
- E. Conduit in finished areas, will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception: metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
- F. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.
- G. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
- H. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
- I. Wire will not be allowed to run across telephone equipment areas.

3.4 Installation Practices for Field Devices

- A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
- B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
- C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
- D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
- E. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
- F. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

3.5 Enclosures

- A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
- B. FIPs shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.
- C. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
- D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
- E. All outside mounted enclosures shall meet the NEMA-4 rating.
- F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

3.6 Identification

- A. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
- B. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.
- C. Junction box covers will be marked to indicate that they are a part of the BAS system.
- D. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.
- E. All I/O field devices inside FIP's shall be labeled.

3.7 Existing Controls.

- A. Existing controls which are to be reused must each be tested and calibrated for proper operation. Existing controls which are to be reused and are found to be defective requiring replacement, will be noted to the Owner.
- B. All existing controllers, thermostats, pneumatic tubing, actuators, panels gauges and any device associated with equipment is to be removed completely. Remove pneumatic lines back to wall or floor and cap airtight

3.8 Control System Switch-over

- A. Demolition of the existing control system will occur after the new temperature control system is in place including new sensors and new field interface devices.

- B. Switch-over from the existing control system to the new system will be fully coordinated with the Owner. A representative of the Owner will be on site during switch-over.
- C. The Contractor shall minimize control system downtime during switch-over. Sufficient installation mechanics will be on site so that the entire switch-over can be accomplished in a reasonable time frame.

3.9 Location

- A. The location of sensors is per mechanical and architectural drawings.
- B. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.
- C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.
- D. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.10 Software Installation

A. General.

The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third-party software necessary for successful operation of the system.

B. Database Configuration.

The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphic Slides.

Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner. Graphically represent each and every piece of equipment in the classroom building, new and existing, all input and put status point, and functional points. This shall include all new HVAC equipment

D. Reports.

The Contractor will configure the following trend data reports for the owner.

- 1. Packaged roof top units
 - a. Unit operating status.
 - b. SA temp and set point
 - c. SA static pressure and set point
 - d. Room temps and set point.
 - e. VAV box status / position.

- f. OA temp and set point
 - g. RA temp and set point
 - h. General fault alarm
 - 2. DOAS Units
 - a. Unit operating status.
 - b. SA temp and set point
 - c. SA static pressure and set point
 - d. Room temps and set point.
 - e. OA temp and set point
 - f. RA temp and set point
 - g. General fault alarm
 - 3. VRF Systems
 - a. Unit operating status.
 - b. Room temps and set point.
 - c. Heating / cooling mode status
 - d. Fan status
 - e. General fault alarms
- E. Commissioning and System Startup
- F. Point to Point Checkout.

Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.
- G. Controller and Workstation Checkout.

A field checkout of all controllers and front-end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.
- H. System Acceptance Testing

All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
- I. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.
- J. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.

- K. Perform an operational test of each third-party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

END OF SECTION 230901

SECTION 230993 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Sequence of operation:
 - 1. General
 - 2. Packaged Roof Top Units
 - 3. VRF System
 - 4. Indoor Evaporators
 - 5. Dedicated Outside Air Units (DOAS)
 - 6. Science Wing Fin Tube
 - 7. Miscellaneous.

1.02 RELATED SECTIONS

- A. Section 23 0901 - Digital Control Equipment.

1.03 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.
- B. Provide DDC based electronic controls, panels, wiring and all accessories required to achieve the specified control sequences and establish a complete system for all new equipment. All new temperature controls shall be networked into the existing Andover Continuum system.
- C. Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment. Each SDCU will operate completely standalone, containing all the I/O and programs to control its associated equipment.
- D. Certain controls are specified to be furnished with the equipment. This contractor shall provide all components, (gateways), to communicate with factory furnished controls and connect them to the building automation control system. The contractor shall also provide all controls, wiring and auxiliaries required to operate equipment not furnished with factory controls. Work required includes, but is not limited to the following:
 - 1. Control wiring between factory mounted unit panels and factory supplied remote panels.
 - 2. Installation and wiring for factory supplied devices requiring field installation.
 - 3. Panel mounted transformers and control power wiring for all controllers and control devices.

4. Control wiring to each remote device (room thermostats, outdoor air sensors, static pressure controllers, control actuators, control panels, etc.).
5. All control valves, motorized dampers thermostats, relays, sensors, etc. unless furnished as an integral part of the equipment.
6. All interlock control wiring (24 volt and 120 volt) between units, fans, etc. All control and interlock wiring shall be run in EMT for indoor locations and in galvanized conduit for outdoor locations.
7. All new controllers, hardware software, programming and accessories shall be Andover continuum system by Schneider Electric.

1.04 SUBMITTALS FOR REVIEW

- A. Division 1 - Submittals: Procedures for submittals.
- B. Shop Drawings: Indicate mechanical system controlled and control system components.
 1. Label with settings, adjustable range of control and limits. Include written description of control sequence.
 2. Include flow diagrams for each control system, graphically depicting control logic.
 3. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
 4. Submit a complete written sequence of operation for each and every controlled piece of equipment.

1.05 SUBMITTALS AT PROJECT CLOSEOUT

- A. Operation and Maintenance Data.
- B. Project Record Documents: Record actual locations of components and set-points of controls, including changes to sequences made after submission of shop drawings.

1.06 QUALITY ASSURANCE

- A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State of New York.

PART 2 - PRODUCTS

- A. Refer to specification section 23 09 01 – Direct Digital Controls

PART 3 - EXECUTION

3.01 SEQUENCE OF OPERATION

- A. General

1. The building automation System (BAS) or Building management System (BMS) shall index the equipment into either summer or winter control based upon outdoor air temperature. Below 65 F, (adjustable), outside air temperature, the cooling shall be disabled. Above 55F, (adjustable), outside air temperature the heating shall disabled. The system operator shall have capacity of overriding the system for manual change over. A minimum time delay, (24 hrs adjustable), between summer/winter changes over shall prevent cycling between the 2 modes. During heating mode, the DX systems shall be locked out.

B. Packaged Roof Top Units

1. General: The units shall be supplied with and operated through a unit mounted or remote DDC unitary control panel, capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers and valves, damper motors, motor starters, wiring, sensors and all hardware accessories for a complete system. The unitary control panel shall be provided by the unit manufacturer or provided by the BMS controls contractor and shall use native BACnet as the operating communications protocol. Furnish wall mounted room thermostats with automatic summer/winter change over, and temperature adjustments.
2. Units Off: The outside air intake and relief air dampers shall be closed, and the return air damper shall be full open. Refrigeration system shall be off.
3. Summer Operation Occupied: Upon start up, the control circuits shall be energized. The supply fan shall run continuously. The outside air intake, and relief air dampers shall open to minimum position the return damper shall open to the maximum position. A temperature sensor in the unit discharge duct shall be used to maintain SA temperature set point. A return air temperature sensor, shall be arranged to reset the discharge air temperature. The discharge air temperature set-point shall be determined through a comparison of return air temperature and SA temp set-point, and shall be reset according or cooling demand. When return air is 80db 67bw the supply air shall be 57db. As return air temperature decreases the SA temp setpoint shall increase. VAV boxes shall operate in the summer mode.
4. Winter Operation Occupied: Upon start up, the control circuits shall be energized. The supply fan shall run continuously. The outside air intake, and relief air dampers shall open to minimum position the return damper shall open to the maximum position. The duct mounted steam coil (SC-1) and associated modulating steam control valve of packaged heat pump system shall be arranged to maintain a supply temperature at 68°F to 72°F range (adjustable). VAV boxes shall operate in the winter mode.
5. Ventilation air: The RTU schedule indicate the minimum OA rate for each AC unit. The percent of OA shall be set according to the schedule at design CFM. Provide an air flow measuring station to monitor OA volume. The BMS shall automatically increase the % of outside air-based

fan speed. The control sequence shall be that as fan speed drops below the nominal, the OA intake damper shall open proportionally to allow increased percent of OA and maintain the minimum fresh air volume. For those units that operate DCV mode during normal occupied hours this function shall be overridden by DCV control.

6. Economizer Operation: On a call for cooling when outdoor air conditions permit, (70 deg, 50% RH), an enthalpy control shall modulate the outside air intake, exhaust and return air dampers, to maintain SA temp set point. (Override DCV as required). Control action shall be that an increase in SA temperature will cause the outside air and exhaust air dampers to modulate towards the open position and the return air damper to modulate towards the closed position. A drop in below set point temperature will cause the reverse to take place. When the outdoor air damper reaches the fully open position a further call for cooling shall cause DX water system to operate. When ambient conditions are no longer suitable for economizer operation the unit controls shall revert to normal summer operation. The power exhaust fan(s) shall be staged and modulated to maintain building positive pressure no greater than +.1" wc.
7. Morning Warm-up Operation: Unit shall start and operate for a predetermined period as determined by the BMS. During this cycle outside intake and exhaust air dampers shall remain closed and return air damper shall be full open. The steam control valve or packaged heat pump shall modulate to maintain set point. When the zone temperature(s) comes to within 2 degrees of set point the unit shall operate in occupied mode.
8. Morning Cool-Down Operation: Unit shall start and operate for a predetermined period as determined by the BMS. The unit shall operate in economizer mode if outdoor air conditions allow it. During this cycle outside intake and spill air dampers shall remain closed and return air damper shall remain open. The cooling coil shall modulate to maintain discharge air temperature set point. When the zone temperature(s) comes to within 2 degrees of set point the unit shall operate in occupied mode.
9. Unoccupied Operation: Unit supply fan, steam control valve and DX system shall cycle on a call for cooling or heating. During this cycle the unit shall operate with 100% re-circulated air. Unit controls shall allow complete shutdown if desired. Set point shall be 65° (set back) in the heating season and 80, (set up) in the cooling season.
10. Limit Controls: Provide a High/low limit control(s) in the supply fan discharge arranged to override temperature controls and prevent discharge temperature from dropping below 50°F and rising above 110°F(adjustable).
11. Freeze stat: Provide unit with a manual reset type freeze stat, (set at 35° adjustable), arranged to shut down the unit and sound an audio and visual alarm at the BAS operator station should the set point be reached. The freeze stat element shall be the capillary type with lowest point

temperature sensing. The alarm be resettable from the operator workstation.

12. Static Pressure Controls: Provide static pressure sensors in the supply ductwork for each unit located approximately two-thirds downstream of the unit. Sensors shall be arranged to vary the speed of the supply in response to supply duct static pressure. An increase in static pressure shall cause the fans to slow down a decrease shall cause the fans to speed up. Static pressure set point shall be established during the balancing process at design flow. (anticipated range is 2" w.c. – 3"w.c.).

C. The VRF system shall be operated through the manufacturers building or system wide controller. AC Smart 5 PACS5A000. The controller shall be programmed so the indoor units are operated in groups. Groups shall be arranged on a floor-by-floor basis and or a department basis. The owner and engineer shall review and approve operating groups.

D. Indoor Evaporators

1. Each indoor unit shall be operated through a programmable room thermostat. PREMTBVCO. Each unit shall be arranged to run continuously during occupied hours. Alternately indoor units can be arranged to cycle during occupied hours. The units are designed for simultaneous heating and cooling operation. The room thermostat shall automatically switch each unit from heating to cooling as required to maintain set point. The thermostat shall also be arranged to modulate fan speed in direct proportion to space load. Thermostats shall be programed with to maintain set point to with in +- 2 deg F. each thermostat shall also be programed to limit set point between 70°-75° F. Rooms with auxiliary hydronic heating elements, (cabinet convectors), shall use an auxiliary relay kit to operate the control valve on the convector from the LG thermostat. The control action shall open the valve on a cool for heating as the second stage of heating.

E. Dedicated Outside Air Units (DOAS)

1. Shall be arranged to operate during scheduled occupied hours. When the units are off. The outside air intake and exhaust dampers shall be closed. The fans shall be off. The DX coil shall be arranged to maintain a supply air temperature of neutral at 70 deg F. Provide outside air temperature and humidity sensors. Provide SA temperature sensors. When OA temp drops below set point the DX coil shall be arranged to heat the SA. When OA temp rises above set point the DX coil shall be arranged to cool the SA. The system shall also be arranged to maintain % RH of the SA at a maximum of 50% RH adjustable. When SA RH rises above set point the unit shall active DX cooling and sub cool the SA in order to reduce RH. The air shall be reheated by use of modulating hot gas reheat coil.
2. Energy Recovery Wheel shall be arranged to run with their respective DOAS unit and shall run continuously. When the units are energized to run the intake and exhaust dampers shall open. When the units are

stopped the dampers shall close. [enthalpy wheel, and fans shall run continuously when the unit is energized to run]. Provide enthalpy controls arranged to allow economizer cycle. When OA temperature and humidity conditions allow economizer to cycle, the unit shall operate in the bypass mode and bypass the heat exchanger and or enthalpy wheel. Provide defrost controls arranged to operate the defrost cycle as per the manufacture's recommendations.

3. Existing Science Classroom Hoods – When the existing hood in Science Classroom 250 is energized, existing damper M1 shall close. DOAS unit shall continue to run and supply 700 CFM to the room while the existing hood is exhausting 770 CFM to keep the room negative. When (1) of the existing hoods in Science Classroom 252 is energized, existing damper M2 shall close. DOAS unit shall continue to run and supply 700 CFM to the room while the existing hood is exhausting 770 CFM to keep the room negative. If both existing hoods in Science Classroom 250 are energized, both damper M2 and M3 shall close. DOAS units shall continue to run and supply 700 CFM to Science Classroom 252 and 700 CFM to Science Classroom 253 while the existing hoods are exhausting 770 CFM to keep the room negative.

F. Science Wing Fin Tube:

1. The BMS controls contractor shall provide a control valve and operator if the existing valve or operator is not working or is not compatible with the new system. The control valves for these units shall be operated through the VRF system room thermostat/controller. The VRF room thermostat/controller shall have two stages of heat. The first stage of heat shall be the convector radiation valves. The valves shall be operated in sequence with the room evaporator. Set point shall be 72°F for each convector. Upon a drop in space temperature below set-point the control valve shall cycle open. On a rise in space temperature above set point the reverse shall take place. The set point shall be adjustable. The second stage of heat shall be the heat pump system.

G. Miscellaneous:

1. Motor starters shall be supplied for each Air Handler, H & V Unit, Fan, pump, etc. When starters are located at the unit, (factory or field installed), or within line of site of the unit combination Starters/disconnects shall be used. All starters shall be equipped with H-O-A switches and pilot lights in cover. For units with remote mounted starters, (i.e. roof-top exhaust fans) furnish disconnects at the unit.
2. All safety devices shall be interlocked with "hand" and "Automatic" positions in series with motor controller holding coil circuit. Interlocking with other fans and equipment of system shall be through "Automatic" position "Hand" position shall be for maintenance only. Remote starting shall be from through "automatic" position only.

3. All air handling units 2,000 cfm or greater shall have a duct mounted smoke detector arranged to stop the unit and position all dampers and valves in the "unit off" sequence as described in this section, upon detecting smoke.

END OF SECTION 230993

SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. The section includes pipe and fittings for LP and HP steam and condensate piping:
 - 1. Steel pipe and fittings.
 - 2. Joining materials.
- B. Related Requirements:
 - 1. Section 232216 "Steam and Condensate Heating Piping Specialties" . for strainers, special-duty valves, steam traps, thermostatic air vents, and vacuum breakers. ,

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Steel pipe and fitting.
 - 2. Joining material.
- B. Delegated-Design Submittal:
 - 1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints, and loops, and attachments of the same to the building structure.
 - 2. Locations of pipe anchors and alignment guides and expansion joints and loops.
 - 3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
 - 4. Locations of and details for penetration and fire stopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, drawn to 3/8" = 1'-0" scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Other building services.

3. Structural members
4. Steam and condensate equipment.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. LP Steam Piping: up to 15psig.
2. HP Steam Piping: over 15 psi.
3. Condensate Piping: 15 PSIG at 250 deg F.
4. Makeup-Water Piping: 75 PSIG at 150 deg F.
5. Blowdown-Drain Piping: Equal to the pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to the pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.
- E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match the adjoining pipe.
- G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of the same Type, Grade, and Schedule as the pipe in which installed.

2.3 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron, and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron, and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and chemical analysis of pipe being welded.
- E. Fiberglass Pipe Adhesive: As furnished or recommended by the pipe manufacturer.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

- A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

- B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- C. Condensate piping above grade, NPS 2 and smaller, shall be the following:
 - 1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:
 - 1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- E. Condensate piping below grade, NPS 2 and smaller shall be the following:
 - 1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- F. Condensate piping below grade, NPS 2-1/2 and larger, shall be the following:
 - 1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 HP STEAM PIPING APPLICATIONS

- A. HP Steam Piping, NPS 2 and Smaller: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- B. HP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- C. Condensate piping above or below grade, NPS 2 and smaller: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints
- D. Condensate piping above or below grade, NPS 2-1/2 and larger: Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints

3.3 ANCILLARY PIPING APPLICATIONS

- A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- B. Vacuum-Breaker Piping: Outlet, same as service where installed.
- C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which the safety valve is installed.

3.4 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate the general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Select system components with a pressure rating equal to or greater than system operating pressure.
- J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of streamflow.
- M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in the direction of condensate flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with the level side down.
- O. Install branch connections to mains using tee fittings in the main pipe, with the branch connected to the top of the main pipe.
- P. Install valves according to the following Sections or other Sections as needed: Do not use butterfly valves in steam or condensate lines or services or steam equipment.
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.
- T. Install strainers on the supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match the size of strainer blowoff connection for strainers smaller than NPS 2.
- U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of all risers, and ahead of pressure regulators, and control valves.
 - 1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
 - 2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
- Z. For piping passing through equipment room walls to occupied spaces provide split seals for sound and vibration attenuation between rooms. Comply with section 23 22 16.
- AA. Install piping to allow for expansion and contraction.

3.5 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

- A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents, and vacuum breakers, and steam and condensate meters.

3.6 HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports and hanger rod size.
- B. Install vibration isolation hangers or supports on all piping connected to motor-driven equipment for a distance of 20' or the first two hangers. Refer to section 232112.13 Hydronic Piping specialties.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers are for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
- D. Install hangers for steel steam supply piping with the following maximum spacing:
 - 1. NPS 3/4: Maximum span, 9 feet.
 - 2. NPS 1: Maximum span, 9 feet.
 - 3. NPS 1-1/2: Maximum span, 12 feet.
 - 4. NPS 2: Maximum span, 13 feet.
 - 5. NPS 2-1/2: Maximum span, 14 feet.
 - 6. NPS 3 and Larger: Maximum span, 15 feet.
- E. Install hangers for steel steam condensate piping with the following maximum spacing:
 - 1. NPS 3/4: Maximum span, 7 feet.
 - 2. NPS 1: Maximum span, 7 feet.
 - 3. NPS 1-1/2: Maximum span, 9 feet.
 - 4. NPS 2: Maximum span, 10 feet.
 - 5. NPS 2-1/2: Maximum span, 11 feet.
 - 6. NPS 3 and Larger: Maximum span, 12 feet
- F. Support vertical runs at the roof, at each floor, and 10-foot intervals between floors.
- G. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

3.7 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and remove the burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to the "Quality Assurance" Article.
- E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- F. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.8 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install traps and control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around a control valve. If parallel control valves are installed, only one bypass is required.
- D. Install vacuum breakers downstream from the control valve, close to coil inlet connection.
- E. Install a drip leg at the coil outlet.

3.9 FIELD QUALITY CONTROL

- A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during the test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush system with clean water. Clean strainers.
 - 4. Isolate equipment from the piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to the valve. Install blinds in flanged joints to isolate equipment.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections:
 - 1. Use ambient temperature water as a testing medium unless there is a risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other components in the system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of the specified minimum yield strength.
 - 3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat the hydrostatic test until there are no leaks.
- E. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Stop-check valves.
3. Steam Safety valves.
4. Steam traps.
5. Thermostatic air vents and vacuum breakers.
6. Vibration isolators for hangers
7. Expansion Fittings
8. Alignment guides and anchors
9. Control valves
10. Shut off valves

- B. Related Requirements:

1. Section 232316 "Steam and Condensate Specialties".

1.3 ACTION SUBMITTALS

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

1. Strainer.
2. Valve.
3. Steam trap.
4. Air vent and vacuum breaker.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
 1. HP Steam Piping: over 15 psig.
 2. LP Steam Piping: up to 15 psig.
 3. Condensate Piping: 15 psig at 250 deg F.
 4. Makeup-Water Piping: 70 psig Insert value at 75 deg F.
 5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
 6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
 7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

- A. Y-Pattern Strainers:
 1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
 3. Strainer Screen: Stainless-steel, 20-mesh strainer or perforated stainless-steel basket.
 4. Tapped blowoff plug.
 5. CWP Rating: 250-psig working steam pressure.
- B. Basket Strainers:
 1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
 3. Strainer Screen: Stainless-steel, 20-mesh strainer and perforated stainless-steel basket with 50 percent free area.
 4. CWP Rating: 250-psig working steam pressure.

2.3 STOP-CHECK VALVES

- A. Stop-Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Jenkins Valves.
 - d. Lunkenheimer Valves.
2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.4 STEAM SAFETY VALVES

A. Bronze or Brass Steam Safety Valves: ASME labeled, NPS 1/2 through NPS 2-1/2

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Armstrong International, Inc.
 - c. Spirax Sarco, Inc.
 - d. Watts; a Watts Water Technologies company.
2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Steam Safety Valves: ASME labeled NPS 1-1/2 through NPS 6.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Armstrong International, Inc.
 - c. Spirax Sarco, Inc.
 - d. Watts; a Watts Water Technologies company.
 - e. Spence

2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.5 STEAM TRAPS

A. Thermostatic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Dunham-Bush, Inc.
 - c. Hoffman Specialty.
 - d. Spirax Sarco, Inc.
 - e. Sterling.
 - f. Tunstall Corporation.
2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Thermodynamic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Dunham-Bush, Inc.
 - c. Hoffman Specialty.
 - d. Spirax Sarco, Inc.
2. Body: Stainless steel with screw-in cap.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig.

C. Float and Thermostatic Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Dunham-Bush, Inc.
 - c. Hoffman Specialty.
 - d. Spirax Sarco, Inc.
2. Body and Bolted Cap: ASTM A 126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

D. Inverted Bucket Steam Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Dunham-Bush, Inc.
 - c. Hoffman Specialty.
 - d. Spirax Sarco, Inc.
2. Body and Cap: Cast iron.
3. End Connections: Threaded.
4. Head and Seat: Stainless steel.
5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
6. Bucket: Brass or stainless steel.
7. Strainer: Integral stainless-steel inlet strainer within the trap body.
8. Air Vent: Stainless-steel thermostatic vent.
9. Pressure Rating: 250 psig.

2.6 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

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

- a. Armstrong International, Inc.
 - b. Dunham-Bush, Inc.
 - c. Hoffman Specialty.
 - d. Spirax Sarco, Inc.
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Dunham-Bush, Inc.
 - c. Hoffman Specialty.
 - d. Spirax Sarco, Inc.
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 deg F.

2.7 VIBRATION ISOLATION PIPE HANGERS

- A. Vibration isolation pipe hangers: pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

2.8 ALIGNMENT GUIDES AND ANCHORS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advanced Thermal Systems, Inc.
 - b. Flexicraft Industries.
 - c. Mason Industries, Inc.
 - d. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
3. Steel Shapes and Plates: ASTM A 36/A 36M.
4. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
5. Washers: ASTM F 844, steel, plain, flat washers.
6. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened concrete, with tension and shear capacities appropriate for application. Threaded stud, expansion plug, nuts and washers shall be zinc-coated carbon steel.
7. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: threaded stud washers and nuts shall be ASTM A 307, zinc-coated carbon steel.
 - c. Alignment Guides
 - 1) Horizontal split spider type guide – Metraflex – Style IV
 - 2) Slide guide - – Metraflex – model PTFE
 - 3) Pre-insulated guide – Metraflex – model PG PRE
 - 4) Vertical glide riser - – Metraflex – model PGQ
 - d. Anchors
 - 1) Anchor clamp – Metraflex – model PA
 - 2) Structural I Beam Anchors – Metraflex
 - 3) Pre-insulated Anchor – Metraflex – model PAPI
 - 4) Modular riser guide – Metraflex – modular riser with EPDM insert

2.9 CONTROL VALVES

- A. Body & Trim. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum: in general valves up to 3" shall be bronze body, valves over 3' shall be iron body.
- B. Valve pattern, angle or straight through, shall be as indicated on Drawings.
- C. Modulating two-way pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
- D. Valve bodies shall meet or exceed pressure and temperature class rating based upon design operating temperature and 150% design operating pressure. Unless otherwise specified or scheduled, minimum body rating for any valve is 125 psi and a maximum fluid temperature of 350°F.

- E. Steam Valves. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
 - 1. Linear percentage ports for modulating service.
 - 2. Two-position service: Pressure drop 10% to 20% of inlet pressure.
 - 3. Modulating service: 15 psig or less; pressure drop 80% of inlet pressure.
 - 4. Modulating service: 16-50 psig or less; pressure drop 50% of inlet pressure.
 - 5. Modulating service: Greater than 50 psig; pressure drop as scheduled
 - 6. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation.
 - 7. Globe valves shall have replaceable seats.
 - 8. Valves on heating systems shall fail open.

2.10 SELF-CONTAINED TEMPERATURE REGULATING VALVE

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Jordan Valve; Richards Industries Company.
 - 2. Spartin
 - 3. Danfoss
- B. Description:
 - 1. Self-contained and self-operated temperature regulating valve. Direct acting or reverse acting as required by application.
 - 2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the valve. The valve shall fail open.
 - 3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the valve. The valve shall fail close.
 - 4. Body: Carbon steel.
 - 5. Trim and Seats: 300 series stainless steel.
 - 6. Yoke: Cast iron.
 - 7. Actuator: 300 series stainless steel.
 - 8. End Connections: Threaded.
 - 9. Capillary, Bulb, and Armor: 300 series stainless steel.
 - 10. Thermal Fill Material: Match to the temperature range.
 - 11. Thermowell: Type 316 stainless-steel thermowell sized to fit the bulb and pipe.
- C. Operational Characteristics: Control flow from between 5 to 100 percent of rated capacity.
- D. Interchangeable trim for one size smaller.
- E. Valve Leakage: Comply with FCI 70-2, Class IV.
- F. Temperature Range: Match application.
- G. Valve Size: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

2.11 SHUT OFF VALVES

A. Class 150 Bronze Angle Valves:

1. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem and Disc: Bronze
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150 Bronze Globe Valves:

1. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Bronze or PTFE.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

C. Class 250 Iron Globe Valves:

1. Description:
 - a. Standard: MSS SP-85, Type I.
 - b. CWP Rating: 500 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Packing and Gasket: Asbestos free.
 - g. Operator: Handwheel or chainwheel.

D. Two-Piece Brass Ball Valves with Full Port and Brass Trim:

1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

E. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:

1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.

- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Bronze.
- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Bronze.
- i. Ball: Chrome-plated brass.
- j. Port: Full.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
- B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

- A. Install piping to permit valve servicing.
- B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- C. Install valves according to Section 230523.10 "Valves for HVAC Piping,"
- D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.
- E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- F. Install shutoff valve immediately upstream of each dielectric fitting.
- G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

3.3 STEAM-TRAP INSTALLATION

- A. Install steam traps in accessible locations as close as possible to connected equipment.
- B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 SAFETY VALVE INSTALLATION

- A. Install safety valves according to ASME B31.1, "Power Piping." ASME B31.9, "Building Services Piping." ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping."
- B. Pipe safety-valve discharge without valves to atmosphere outside the building.
- C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
- D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.5 TERMINAL EQUIPMENT CONNECTIONS

- A. Install traps and control valves in accessible locations close to connected equipment.
- B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

3.6 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.7 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.8 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint or loop not more than three pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.9 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 4.

E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.

F. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
 2. Align threads at point of assembly.
 3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
 4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.
- I. Flanged Valves:
1. Align flange surfaces parallel.
 2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

END OF SECTION 232216

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Refrigerant pipes and fittings.
 - 2. Refrigerant piping valves and specialties.
 - 3. Refrigerants.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
 - 1. Include pressure drop, based on manufacturer's test data, for the following:
 - a. Thermostatic expansion valves.
 - b. Solenoid valves.
 - c. Hot-gas bypass valves.
 - d. Filter dryers.
 - e. Strainers.
 - f. Pressure-regulating valves.
- B. Shop Drawings:
 - 1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
 - 2. Show interface and spatial relationships between piping and equipment.
 - 3. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-134a:
 - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
 - 2. Suction Lines for Heat-Pump Applications: 225 psig.
 - 3. Hot-Gas and Liquid Lines: 225 psig.
- B. Line Test Pressure for Refrigerant R-407C:
 - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
 - 2. Suction Lines for Heat-Pump Applications: 380 psig.
 - 3. Hot-Gas and Liquid Lines: 380 psig.
- C. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type L – Refer to section 3 for applications
- B. ASTM B 280, Type ACR. – Refer to section 3 for applications
- C. Wrought-Copper Fittings: ASME B16.22.
- D. Wrought-Copper Unions: ASME B16.22.

- E. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- F. Brazing Filler Metals: AWS A5.8/A5.8M.
- G. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Working Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.
- H. Flexible Connectors:
 - 1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
 - 2. End Connections:
 - a. NPS 2 and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 and Larger: With flanged-end connections.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

- A. Manufactures:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Paul Mueller Company.
 - d. Danfoss Inc.
 - e. Parker Hannifin Corp.
 - f. Keep-Rite Co.
- B. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.

5. End Connections: Socket, union, or flanged.
 6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 275 deg F.
- C. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze
 2. Packing: Molded stem, back seating, and replaceable under pressure.
 3. Operator: Rising stem.
 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 5. Seal Cap: Forged-brass or valox hex cap.
 6. End Connections: Socket, union, threaded, or flanged.
 7. Working Pressure Rating: 500 psig.
 8. Maximum Operating Temperature: 275 deg F.
- D. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
 2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
 3. Piston: Removable polytetrafluoroethylene seat.
 4. Closing Spring: Stainless steel.
 5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
 6. End Connections: Socket, union, threaded, or flanged.
 7. Maximum Opening Pressure: 0.50 psig.
 8. Working Pressure Rating: 500 psig.
 9. Maximum Operating Temperature: 275 deg F.
- E. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
 2. Core: Removable ball-type check valve with stainless-steel spring.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Copper spring.
 5. Working Pressure Rating: 500 psig.
- F. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
1. Body and Bonnet: Plated steel.
 2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
 6. Working Pressure Rating: 400 psig.
 7. Maximum Operating Temperature: 240 deg F.
- G. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Threaded.

5. Working Pressure Rating: 400 psig.
 6. Maximum Operating Temperature: 240 deg F.
- H. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 5. Suction Temperature: 40 deg F.
 6. Superheat: Adjustable or Nonadjustable.
 7. Reverse-flow option (for heat-pump applications).
 8. End Connections: Socket, flare, or threaded union.
 9. Working Pressure Rating: 700 psig.
- I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 5. Seat: Polytetrafluoroethylene.
 6. Equalizer: Internal or External.
 7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 24-V ac coil.
 8. End Connections: Socket.
 9. Throttling Range: Maximum 5 psig.
 10. Working Pressure Rating: 500 psig.
 11. Maximum Operating Temperature: 240 deg F.
- J. Straight-Type Strainers:
1. Body: Brass or welded steel with corrosion-resistant coating.
 2. Screen: 100-mesh stainless steel.
 3. End Connections: Socket or flare.
 4. Working Pressure Rating: 500 psig.
 5. Maximum Operating Temperature: 275 deg F.
- K. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
 2. Drain Plug: Brass hex plug.
 3. Screen: 100-mesh monel.
 4. End Connections: Socket or flare.
 5. Working Pressure Rating: 500 psig.
 6. Maximum Operating Temperature: 275 deg F.
- L. Moisture/Liquid Indicators:
1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in parts per million (ppm).
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.

6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 240 deg F.
- M. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina or charcoal.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig.
 8. Rated Flow: .
 9. Working Pressure Rating: 500 psig.
 10. Maximum Operating Temperature: 240 deg F.
- N. Permanent Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina or charcoal.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig.
 8. Rated Flow: .
 9. Working Pressure Rating: 500 psig.
 10. Maximum Operating Temperature: 240 deg F.
- O. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
 2. End Connections: Socket or flare.
 3. Working Pressure Rating: 500 psig.
 4. Maximum Operating Temperature: 275 deg F.
- P. Receivers: Comply with AHRI 495.
1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 2. Comply with UL 207; listed and labeled by an NRTL.
 3. Body: Welded steel with corrosion-resistant coating.
 4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
 5. End Connections: Socket or threaded.
 6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 275 deg F.
- Q. Liquid Accumulators: Comply with AHRI 495.
1. Body: Welded steel with corrosion-resistant coating.
 2. End Connections: Socket or threaded.
 3. Working Pressure Rating: 500 psig.

4. Maximum Operating Temperature: 275 deg F.

R. FLEXIBLE CONNECTORS

1. Corrugated stainless steel bronze hose with single layer of stainless steel exterior braiding, minimum 6 inches long with copper tube ends; for maximum working pressure 500 psi.

2.4 REFRIGERANTS

- A. ASHRAE 34, R-134a: Tetrafluoroethane.
- B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
- C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT:

- A. All refrigerant piping shall meet the equipment manufacturers requirements and recommendations.
- B. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K or Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.
- E. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.
- F. Safety-Relief-Valve Discharge Piping: Copper, Type K or Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.
 1. Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

- B. Install refrigerant piping according to ASHRAE 15 and in accordance the unit manufactures guidelines. Maintain refrigerant velocities within manufactures recommendations in order to keep oil entrained.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.

- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - 1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - 2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - 4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 - 5. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open, to allow unrestricted flow.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
- W. Install refrigerant piping to allow expansion and contraction of piping without deformation or bending or sagging. Provide expansion fittings, bends or elbows to allow expansion in accordance with manufactures temperature operating range.

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.
- F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

- A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.

5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
 6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
 7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
 8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
 9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.
- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8 inch.
 2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8 inch.
 3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8 inch.
 4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2 inch.
- E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Comply with ASME B31.5, Chapter VI.
 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 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.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Verify that compressor oil level is correct.
 - 3. Open compressor suction and discharge valves.
 - 4. Open refrigerant valves except bypass valves that are used for other purposes.
 - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.

- B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

Retain first paragraph below if Contractor is required to assume responsibility for duct construction design.

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
 1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
 2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.

3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

Retain paragraph below to comply with sustainable design schemes that require compliance with ASHRAE 62.1.

- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

- B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment.
13. Seismic restraints, where applicable
14. Vibration isolation.

Paragraph below is defined in Section 013300 "Submittal Procedures" as a "Delegated-Design Submittal." Retain with "Performance Requirements" Article if design responsibilities have been delegated to Contractor.

- C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints. For seismic bracing only

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - 2. Suspended ceiling components.
 - 3. Structural members to which duct will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Penetrations of smoke barriers and fire-rated construction.
 - 6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
- B. Welding certificates.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- D. Construct ductwork to NFPA 90A and NFPA 90B standards. All work, materials and equipment shall comply with the latest requirements of NFPA 90A, standards and the local authorities having jurisdiction.
- E. All ductwork and fan and apparatus plenums constructed and having supported in accordance with the latest standards of the ASHRAE Guide and the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- F. Bracing, gauges, and supports indicated in SMACNA manuals are the minimum acceptable. Additional bracing or supports shall be installed to eliminate any distortion or vibration when the systems are operating or under tests.

ASHRAE/IES 90.1 requires leakage testing for representative sections totaling no less than 25 percent of installed duct area for ducts designated to operate at a static-pressure class in excess of 3-inch wg (750 Pa). Consider building a mockup of typical portions of the system that can be tested early in the construction process. This standard, as enforced by some authorities having jurisdiction, requires duct systems with static-pressure classes in excess of 3-inch wg (750 Pa) to be identified on Drawings.

PART 2 - PRODUCTS

2.1 General

- A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.
- B. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz per sq ft for each side in conformance with ASTM A90.
- C. Dissimilar Metals: Separate connections between dissimilar metals with Dielectric Insulation. Joints between dissimilar metal duct sections to be made with Companion flanges separated by a Neoprene gasket.
- D. Fasteners: Rivets, bolts, screens, and other hardware used in the sheet metal construction to be constructed of materials identical or similar to the duct material to prevent galvanic corrosion.
- E. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic as manufactured by 3M Company EC-800.
- F. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

Manufacturers and products listed in SpecAgent and Masterworks Paragraph Builder are neither recommended nor endorsed by the AIA or ARCOM. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications. For definitions of terms and requirements for Contractor's product selection, see Section 016000 "Product Requirements."

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

See "Static-Pressure Classes" and "Leakage and Seal Classes" articles in the Evaluations for discussion on fabrication.

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

Retain manufacturer list to require factory-fabricated, double-wall rectangular ducts and fittings; delete to allow shop-fabricated ducts and fittings.

- A. Provide products from one of the following manufactures
 - 1. McGill Airflow LLC
 - 2. Zen Industries
 - 3. Lindab
 - 4. Spiral Manufacturing Co. Inc
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

Retain one of first two paragraphs below. If the objective of interstitial insulation includes achievement of both thermal performance and sound absorption, then ducts may need additional external insulation to achieve the thermal portion of the objective. See

Section 230713 "Duct Insulation" for applicable duct insulation and installation requirements for external duct application.

- F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard." For standard applications

Retain first subparagraph below to require thermal conductivity exceeding the requirements in ASTM C 1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.

Retain subparagraph below for additional protection of airstream.

4. Cover insulation with polyester film complying with UL 181, Class 1.
- G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B. For Humid and damp area applications including Natatoriums and Saunas.
1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 3. Coat insulation with antimicrobial coating.
 4. Cover insulation with polyester film complying with UL 181, Class 2.
- H. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.
- I. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- J. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

See "Static-Pressure Classes" and "Leakage and Seal Classes" articles in the Evaluations for discussion on fabrication.

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

Retain manufacturer list to require factory-fabricated, single-wall round and flat-oval ducts and fittings; delete to allow shop-fabricated ducts and fittings.

- B. Provide products from one of the following manufactures
1. McGill Airflow LLC
 2. Zen Industries
 3. Lindab
 4. Spiral Manufacturing Co. Inc
- C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

Option in subparagraph below is SMACNA's requirement. Insert smaller dimension for more stringent requirement.

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- F. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

Retain manufacturer list to require factory-fabricated, double-wall round and flat-oval ducts and fittings; delete to allow shop-fabricated ducts and fittings.

- A. Provide products from one of the following manufactures

1. McGill Airflow LLC
 2. Zen Industries
 3. Lindab
 4. Spiral Manufacturing Co. Inc
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

Option in subparagraph below is SMACNA's requirement. Insert smaller dimension for more stringent requirement.

- a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

Retain one of two paragraphs below. If the objective of interstitial insulation includes achievement of both thermal performance and sound absorption, then ducts may need additional external insulation to achieve the thermal portion of the objective. See Section 230713 "Duct Insulation" for applicable duct insulation and installation requirements for external duct application.

- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard." For standard applications.
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.
- A. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B. For application in damp or humid environments including natatoriums and Saunas.
- B. Retain subparagraph below to require thermal conductivity exceeding the requirements in ASTM C 1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.
 - 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2.6 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

See "Sheet Metal Materials" Article in the Evaluations for discussion on applicable materials and coatings in first six paragraphs below.

- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.

Most sheet metal suppliers can provide a 4-mil- (0.10-mm-) thick coating on both sides.

- 2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
- 3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

- D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

Antimicrobial coating in first paragraph below is an optional feature and usually applied only after fabrication to ducts fabricated with galvanized sheet steel. See Evaluations for discussion on coatings.

- G. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: Black OR White.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- I. 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.

2.7 DUCT LINER

If the objective of duct liner includes achievement of both thermal performance and sound absorption, then ducts may need additional external insulation to achieve the thermal portion of the objective. See Section 230713 "Duct Insulation" for applicable duct insulation and installation requirements for external duct application.

Sustainable design schemes require that duct insulation R-value comply with ASHRAE/IES 90.1 tables titled "Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts" and "Minimum Duct Insulation R-Value, Combined Heating and Cooling Supply

Ducts and Return Ducts." If using liner alone to satisfy thermal requirements, verify that material selected is available in thickness needed to provide thermal performance without jeopardizing other requirements.

Type I duct liner is available in thicknesses of 1/2 to 2 inches (13 to 50 mm) in 1/2-inch (13-mm) increments; Type II duct liner is available in thicknesses of 1 to 2 inches (25 to 50 mm) in 1/2-inch (13-mm) increments. Indicate thicknesses on Drawings or in the "Duct Schedule" Article.

When specifying duct liner by referencing ASTM C 1071, specifiers are assured of product qualifications for corrosiveness, water-vapor sorption, fungi resistance, temperature resistance, erosion resistance, odor emission, surface-burning characteristics, apparent thermal conductivity, sound absorption coefficients, bacteria resistance, and combustion characteristics.

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

Retain first subparagraph below to require thermal conductivity exceeding the minimum requirements in ASTM C 1071. Retaining subparagraph may create a restrictive proprietary specification.

- a. Maximum Thermal Conductivity:

Option for thermal conductivity in first two subparagraphs below exceeds the values in ASTM C 1071. If retaining, verify availability of performance with duct liner manufacturers.

- 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
- 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature. (For application in damp or humid environments including natatoriums and Saunas).

Antimicrobial coating in first subparagraph below is an optional feature for duct liner.

- 2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
- 3. Solvent Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

Subparagraph below applies to LEED 2009 NC, CI, and CS; LEED v4; IgCC; ASHRAE 189.1; and Green Globes. VOC content limit is that for fiberglass.

Flexible elastomeric duct liner in first paragraph below is not suitable for temperatures higher than 220 deg F (104 deg C).

- B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

Available thicknesses for flexible elastomeric duct liner are 3/8, 1/2, 3/4, and 1 inch (10, 13, 19, and 25 mm). Indicate thickness on Drawings or in the "Duct Schedule" Article.

Surface-burning characteristics in first subparagraph below are available in limited thicknesses. Verify maximum thickness with manufacturers.

1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- C. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- D. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel, aluminum, or stainless steel to match ductwork; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. 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.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

Delete first subparagraph below if air velocities do not exceed 2500 fpm (12.7 m/s).

6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

Securing method in first subparagraph below is for ducts with air velocities of 2500 fpm (12.7 m/s) and lower. Use caution when designing lined ducts with air velocities higher than 2500 fpm (12.7 m/s). See SMACNA for requirements.

7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. 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 higher than 2500 fpm or where indicated.
9. 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.

2.8 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

See SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for discussion on seam and joint sealing methods and their applications. Retain one or more of first three paragraphs below, and identify which sealing system applies to which duct system in the "Duct Schedule" Article.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

Retain one of first two paragraphs below. If retaining second paragraph, verify acceptability with authorities having jurisdiction.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

O-ring seals are generally available for duct fittings 3 to 24 inches (76 to 610 mm) in diameter.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.

Retain one or both subparagraphs below. These are proprietary seals provided on factory-fabricated, round duct fitting joints and constructed with specific dimensions to ensure a proper seal.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.9 HANGERS AND SUPPORTS

Indicate the extent of corrosive environment on Drawings.

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.10 SEISMIC-RESTRAINT DEVICES

Coordinate specifications for seismic-restraint components in this article with structural engineer and with Drawings. See the "Seismic Considerations" Article in the Evaluations for discussion on seismic restraints.

See the Evaluations in Section 230548 "Vibration and Seismic Controls for HVAC" for discussion on seismic-restraint capacities and rating services.

- A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

- B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- C. Restraint Cables: ASTM A 603, galvanized or ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

Retain first paragraph below for strengthening resistance of hanger rods against seismic forces that may cause rods to buckle. Use with either channel- or cable-type bracing assemblies. Detail fabrication and indicate locations on Drawings.

- D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

Coordinate duct layout and duct accessory arrangement with Drawings.

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths and with fewest possible joints
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 0 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness and with sufficient space around equipment to allow normal operating and maintenance

activities. Provide easements where ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.

- H. Provide standard 45-degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for all installations as well as fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- M. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- N. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound.
- O. 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 are used, provide airfoil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
- P. Where ductwork penetrates roofs or outside walls, seal the space around ductwork airtight with fire rated expanding spray foam sealer similar to 3-M Fire Block Foam. This also applies to duct roof penetrations into roof curbs.
- Q. All ductwork shall be inspected and pressure tested prior to enclosing in general construction or concealment above hung ceilings

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.
- F. Prime ductwork and paint with one coat enamel base paint. Color as per architectural plans. All ductwork surface finish shall be treated prior to priming by "pickling" in accordance with industry standards and paint manufactures requirements.
- G. All ductwork in any building that is exposed to view, (except mechanical equipment rooms), shall double wall round ductwork or oval as indicated on plan. Where ductwork is to be painted, it shall be primed. Refer to the architectural plans for where ductwork shall be painted. Submit paint color chart for review and approval. Primer shall be specifically formulated for galvanized steel.
- H. Duct sealants used on exposed ductwork of any type shall be clear.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. No 16 USSG black steel.
- B. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- C. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Cleanout doors on horizontal duct shall be mounted on side of duct. Bottom edge shall be not less than 2 inch above bottom of duct. Cleanout doors at vertical ducts shall be mounted at base. Door and frame shall be same gauge as duct. Hinges shall be Ventlock No. 260, extra heavy zinc plated. Latches shall be Ventlock No. 140, cast zinc. Gaskets shall be between door and frame. Gaskets shall be 1/8 inch double thickness rated for 2000 degree F. Cleanout door size shall be 24 inch one side, and other side shall be 2 inch less than duct height. Where openings are to large for side installation the opening shall be installed on the top or bottom, in accordance with approved methods. Where duct dimensions preclude top or bottom installation install clean outs ON THE duct face that will allow the largest opening with edges as described above.
- D. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
- E. All seams, joints and penetrations shall be liquid tight continuous external arc welded, except where the duct stub collar of the hood is connected to the exhaust duct.

Connection to the hood shall be continuous liquid tight external arc welded or in accordance with the NFPA 96.

- F. Angle reinforcing shall be minimum 1 1/2 inch X 1 1/2 inch X 3/16 inch at maximum 4 ft. on centers and in accordance with SMACNA Rectangular Industrial Duct Contraction Standards shall be mounted.
- G. Duct to hood joints shall be made with continuous liquid tight external welds. Alternatively, the joint shall be made by flange. Flanges shall be 1" wide full perimeter fully welded. Flange connections shall have gaskets rated for 1500°f, secured by .25" dia (minimum) bolts on 4" centers for the full perimeter secured with lock washers.
- H. Duct to fan connections shall be made in a similar fashion as duct to hood connections. Where vibration isolation is required, flexible duct connections to fans shall be made coated fabric flexible connectors listed & labeled for the application.
- I. Horizontal grease ducts less than 75' long shall be installed to slope toward hoods at a rate of 3" per foot. Horizontal grease ducts of 75' or longer shall slope toward hoods at a rate of 1" per foot.
- J. Commercial kitchen exhaust duct insulation: 1" fire resistant duct wrap consisting of light weight, non-asbestos high temperature non-organic ceramic fiber blanket encapsulated in foil/scrim having a service temperature rating of 2300° f. Wrap shall be applied in two layers to provide a two-hour rated enclosure assembly. Bonding material shall be 304 stainless steel, 3/4" wide and .015" thick. Install layers as per the manufactures details and specifications to achieve the required fire rating.

3.4 DUCT SEALING

Retain one of two paragraphs below. Retain first paragraph if retaining subparagraphs for seal class and leakage class in "Duct Schedule" Article; otherwise, delete first and retain second paragraph.

Retain paragraph below for compliance with ASHRAE/IES 90.1, in which Section 6.4.4.2.1 - "Duct Sealing" requires a minimum seal class for various duct locations and pressures indicated in paragraph below.

- A. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" Refer to the Duct Leakage and seal Classification Table below.

Leakage and Seal Classification Table			
Duct Class	1/2"-1", 2" wg	3" wg	4", 6", 10"wg
Sealing Applicable	Transverse Joints Only	Transverse Joints and Seams	Joints, Seams & all Wall penetrations
Leakage Class (C _l) - CFM leakage per 100 SF @ 1" H ₂ O			
Rectangular Metal	24	12	6
Round Metal	12	6	3

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

Verify attachment selection and spacing in first two paragraphs below with structural engineer.

- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

Retain subparagraph below for Projects that require seismic restraints.

5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- G. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound.

- H. Where ceiling or sheetrock has to be opened for the installation of hangers, the contractor shall patch to match existing.
- I. Where fire proofing is removed from structural members for the installation of hangers and supports the contractor shall re-fireproof the member to match the existing material and fireproof rating.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." ASCE/SEI 7.

Options for 40 and 80 feet (12 and 24 m) in first subparagraph below are recommended by SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Revise these dimensions based on the configuration of duct and the seismic hazard.

- 1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 2. Brace a change of direction longer than 12 feet.
- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service or an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 CONNECTIONS

Coordinate duct installations and specialty arrangements with Drawings.

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- C. Smoke purge supply and exhaust systems and stair pressure systems. Flexible connection shall be permitted at diffusers, a maximum of 3' long, and flexible connections are permitted at air handling equipment for vibration isolation only.
- D. INSULATED FLEXIBLE DUCTS
 1. UL 181, Class 0, interlocking spiral of aluminum foil; fiberglass insulation; polyethylene vapor barrier film.
 2. Pressure Rating: 8 inches WG positive or negative.
 3. Maximum Velocity: 5000 fpm
 4. Temperature Range: -20 degrees F to 250 degrees F.

3.8 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

Retain first paragraph below for ducts in pressure classes 3-inch wg (750 Pa) and higher or if applying for sustainable design certification. It may not be economically practical to test ducts in pressure classes less than 3-inch wg (750 Pa).

- B. Leakage Tests:
 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 2. Test the following systems:

Sustainable design requiring compliance with ASHRAE/IES 90.1 must meet the requirements of Section 6.4.4.2.2 - "Duct Leakage Tests," which requires leak testing of at least 25 percent of total installed duct area with a pressure class in excess of 3-inch wg (750 Pa). Retain first subparagraph below for minimum requirements if applying for sustainable design certification or complying with ASHRAE/IES 90.1. To define more stringent requirements, retain subsequent

subparagraphs as applicable and delete first subparagraph. Consider cost impact when specifying the extent of duct area to be tested. It is not common to leak test all ducts or ducts with a pressure class less than 3-inch wg (750 Pa).

- a. All Ducts with a Pressure Class equal to or Higher Than 2-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each system of the designated pressure class.
 - b. All smoke purge system Ducts, including supply exhaust and return air. All stair pressurization ductwork. Test representative duct sections totaling no less than 50 percent of total installed duct area of each system.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 4. Test for leaks before applying external insulation.
 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 6. Give seven days' advance notice for testing.

Retain "Duct System Cleanliness Tests" Paragraph below if duct cleaning is required or if applying for sustainable design certification. Sustainable design requiring compliance with ASHRAE 62.1 must meet Section 7.2.4 - "Ventilation System Start-up," which requires that distribution systems be clean of dirt and debris. Text was taken from NADCA ACR, dated 2005.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
- a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

See Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.10 DUCT CLEANING

Retain this article for applications where construction dust and debris in duct system must be removed before air-system operation, or if applying for sustainable design certification.

Sustainable design requiring compliance with ASHRAE 62.1 must meet the requirements of Section 7.2.4 - "Ventilation System Start-up," which requires that distribution systems be clean of dirt and debris.

- A. Clean new and existing duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.11 SMOKE AND HEAT DETECTOR INSTALLATION

- A. Duct mounted smoke and heat detectors will be supplied under the Electrical Division. This Contractor to coordinate duct sizes and provide labor to install sensing probes into ductwork.

3.12 DUCTWORK PROTECTION

- A. Duct work under construction or alteration shall not be left open ended during dust producing construction. All new and existing ductwork systems in the area of alteration or under construction shall be protected during construction. Open ends ducts shall be sealed with sheet metal or as approved.
- B. For unenclosed buildings ductwork shall be kept dry and water tight. Seal open ends water tight during construction to prevent water infiltration. Keep all acoustical lining dry during construction. Lining that has become wet shall be replaced. All incomplete ductwork being used to condition spaces in phase I or phase II that will be completed under a later phase must be protected from being internally contaminated by construction dust. All returns opening must have filters placed over them to prevent dust from being returned to the unit.

3.13 DUCT SCHEDULE

- A. Fabricate ducts using the following material;
 1. Underground Ducts: Concrete-encased PVC-coated galvanized steel, or Concrete-encased stainless steel, or fiberglass.
 2. Natatorium ductwork – PVC coated galvanized steel.
 3. Kitchen exhaust – welded stainless steel or black steel
 4. Smoke purge ductwork - welded stainless steel or black steel.
 5. Shower room exhaust – aluminum
 6. Dryer exhaust – aluminum
 7. Outside air intake plenum and ductwork - Aluminum
 8. Above ground in MER, conditioned space or unconditioned spaces – galvanized steel

B. Duct Pressure class.

1. All duct systems shall be constructed to have a pressure classification based on the maximum static pressure (positive or negative) developed by the air handling apparatus connected to the ductwork system. Unless otherwise noted below, refer to the equipment schedules and equipment notes for the design operating pressure of each system. Systems with operating pressures between pressure classes shall be constructed to the next higher-pressure class.

Pressure Classification Table						
System operating pressure (OP) in wc	OP≤1"	1"≥OP<2"	2"≥OP<3"	3"≥OP<4"	4"≥OP<6"	6"≥OP<10"
SMACNA Construction classification	1"	2"	3"	4"	6"	10"

2. All ductwork shall be constructed in accordance with the leakage and seal classification. Note that the leakage and seal classification required by current code is more stringent than SMACNA requirements.

Leakage and Seal Classification Table					
System operating pressure in wc			<2" low	2"≥med<3"	High≥3"
Seal Class			C	B	A
Sealing			Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor - Rectangular me			24	12	4
Leakage class CL factor - round metal			12	6	3

Retain applicable subparagraphs in this article to set criteria for pressure class, duct seal-class level, and duct-leakage class; or delete applicable subparagraphs and indicate pressure class, duct seal-class level, and duct-leakage class on Drawings. If retaining duct seal and leakage requirements in this article, retain first paragraph in "Duct Sealing" Article. Both seal class and leakage class are included in this article and either one can be deleted, or both can remain if they are consistent.

Paragraphs below are examples of broad system classifications. Revise to suit Project or indicate requirements on Drawings if a more refined classification is required.

See ASHRAE duct leakage recommendations in 2012 ASHRAE HANDBOOK - "HVAC Systems and Equipment," Chapter 19, "Duct Construction."

Sustainable design requiring compliance with ASHRAE/IES 90.1 must meet the requirements of 6.4.4.2.1 - "Duct Sealing," which requires a minimum seal-class level (A, B, or C) for various duct locations and pressures and specifies seal-class levels for joints and seams in ducts located outdoors, in unconditioned spaces, and in conditioned spaces. Retain second paragraph in "Duct Sealing" Article if applying for sustainable design certification and requirements are not defined in this article or on Drawings.

C. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. PVC-Coated Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
3. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
4. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

D. Liner for sound attenuation:

1. Supply, Return and exhaust air ducts: ½" inches thick.
2. Supply and return fan Plenums: 1" inches thick.
3. Transfer Ducts: 1 inch thick.
4. Ductwork downstream from VAV boxes for 15' minimum
5. At the inlet and discharge of all fans for a distance of 20'

Sustainable design requiring compliance with ASHRAE/IES 90.1 must have duct insulation with an R-value that complies with tables titled "Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts" and "Minimum Duct Insulation R-Value, Combined Heating and Cooling Supply Ducts and Return Ducts." If using liner alone to satisfy thermal requirements, verify that material selected is available in thickness needed to provide thermal performance without jeopardizing other requirements.

Flexible elastomeric insulation is available in thicknesses through 1-1/2 inches (38 mm), which comply with NFPA 90A. Some options in subparagraphs below may create a restrictive proprietary specification. Verify availability of performance with manufacturers.

Retain one option for material and one option for thickness, or insert another thickness, in each of six subparagraphs below.

Sustainable design requiring compliance with ASHRAE/IES 90.1 must have duct insulation with an R-value that complies with tables titled "Minimum Duct Insulation R-Value, Cooling and Heating Only Supply Ducts and Return Ducts" and "Minimum Duct Insulation R-Value, Combined Heating and Cooling Supply Ducts and Return Ducts." If using interstitial insulation

alone to satisfy thermal requirements, verify that material selected is available in thickness needed to provide thermal performance without jeopardizing other requirements.

E. Double-Wall Duct Interstitial Insulation:

1. Supply, Return, Exhaust Air Ducts: 1" inches thick. (when ducts are exposed in the conditions space)
2. Supply, Return, Exhaust Air Ducts: 1 1/2" inches thick. (when ducts are concealed in plenums or are located in unconditioned spaces)

F. Elbow Configuration:

Retain one of first two subparagraphs below. Retain first subparagraph to set different requirements for various velocities. Retain second subparagraph to set the same requirements for all velocities.

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

- c. Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

Retain first three subparagraphs below, or delete and retain fourth subparagraph.

- 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
- b. Round Elbows, 12 Inches and Smaller in Diameter:
- c. Round Elbows, 14 Inches and Larger in Diameter:

Delete paragraph below if branch fittings are detailed on Drawings.

G. Branch Configuration:

- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
- 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.14 DUCTWORK PRESSURE TESTING

- A. All high-pressure ductwork design or operated at 3wc or greater shall pressure tested in accordance with specification section 23 05 93 Testing Adjusting and Balancing.

- B. The contractor review test report results and repair or replace any sections of ductwork with and air leakage rate over 4.0

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Flexible connectors.
16. Duct security bars.
17. Duct accessory hardware.
18. Duct Roof Supports

- B. Related Requirements:

1. Section 233113 Metal Ducts

1.3 ACTION SUBMITTALS

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

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances, and

method of field assembly into duct systems and other construction. Include the following:

- a. Special fittings.
- b. Manual volume damper installations.
- c. Control-damper installations.
- d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
- e. Duct security bars.
- f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.
- B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 1. Galvanized Coating Designation: G90.

2. Exposed-Surface Finish: Mill phosphatized.

- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- C. Aluminum Sheets: Comply with 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: Comply with 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 minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. Pottorff.
 - 4. Ruskin Company.
 - 5. Buckley
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: up to 6"wc.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel] 0.063-inch-thick extruded aluminum [0.03-inch-thick stainless steel, with welded corners or mechanically attached and mounting flange.
- F. Blades: Multiple single-piece blades, center pivoted, or off-center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum or 0.050-inch-thick aluminum sheet noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Galvanized, steel Stainless steel, or Aluminum.
 - 2. Diameter: 0.20 inch min.

- J. Tie Bars and Brackets: Aluminum or Galvanized steel.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball or synthetic pivot bushings.
- M. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Electric actuators.
 - 4. Chain pulls.
 - 5. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20 gage minimum.
 - b. Sleeve Length: 6 inches minimum.
 - 6. Screen Mounting: Rear mounted.
 - 7. Screen Material: Galvanized steel or Aluminum.
 - 8. Screen Type: Bird. $\frac{1}{2}$ x $\frac{1}{2}$ max opening
 - 9. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. Pottorff.
 - 4. Ruskin Company.
 - 5. Buckley
- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: upto 6-inch wg.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel 0.063-inch-thick extruded aluminum 0.05-inch-thick stainless steel, with welded corners or mechanically attached and mounting flange.
- F. Blades:
 - 1. Multiple, 0.025-inch-thick, roll-formed aluminum or 0.050-inch-thick aluminum sheet.
 - 2. Maximum Width: 6 inches.
 - 3. Action: Parallel.
 - 4. Balance: Gravity.

- 5. Eccentrically pivoted or Off-center pivoted.
 - G. Blade Seals: Neoprene.
 - H. Blade Axles: Galvanized steel, aluminum, or Stainless steel.
 - I. Tie Bars and Brackets:
 - 1. Material: Aluminum or Galvanized steel.
 - 2. Rattle free with 90-degree stop.
 - J. Return Spring: Adjustable tension.
 - K. Bearings: Synthetic, Stainless steel, Bronze.
 - L. Accessories:
 - 1. Flange on intake.
 - 2. Adjustment device to permit setting for varying differential static pressures.
- 2.5 MANUAL VOLUME DAMPERS
- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Tek Group.
 - b. McGill AirFlow LLC.
 - c. Nailor Industries Inc.
 - d. Pottorff.
 - e. Ruskin Company.
 - f. Vent Products Co., Inc.
 - g. Buckley
 - 2. Standard leakage rating, with linkage outside airstream.
 - 3. Suitable for horizontal or vertical applications.
 - 4. Frames:
 - a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.

- d. Galvanized or Stainless-steel, 0.064 inch thick.
 - 6. Blade Axles: Galvanized steel, Stainless or steel Nonferrous metal.
 - 7. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 8. Tie Bars and Brackets: Galvanized steel.
- B. Standard, Aluminum, Manual Volume Dampers:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - e. Vent Products Co., Inc.
 - 2. Standard leakage rating, with linkage outside airstream.
 - 3. Suitable for horizontal or vertical applications.
 - 4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
 - 6. Blade Axles: Galvanized steel or Stainless steel.
 - 7. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, or Stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 8. Tie Bars and Brackets: Aluminum.
- C. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - e. Vent Products Co., Inc.
 2. Comply with AMCA 500-D testing for damper rating.
 3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 4. Suitable for horizontal or vertical applications.
 5. Frames:
 - a. U or Angle shaped.
 - b. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized or Stainless, roll-formed steel, 0.064 inch thick.
 7. Blade Axles: Galvanized steel or Stainless steel.
 8. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 9. Blade Seals: Neoprene.
 10. Jamb Seals: Cambered stainless steel or aluminum.
 11. Tie Bars and Brackets: Galvanized steel or Aluminum.
 12. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- D. Low-Leakage, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGill AirFlow LLC.

- b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - e. Vent Products Co., Inc.
 - 2. Comply with AMCA 500-D testing for damper rating.
 - 3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 - 4. Suitable for horizontal or vertical applications.
 - 5. Frames: U or Angle-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
 - d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
 - 7. Blade Axles: Galvanized steel, Stainless steel.
 - 8. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 9. Blade Seals: Neoprene.
 - 10. Jamb Seals: Cambered stainless steel, aluminum.
 - 11. Tie Bars and Brackets: Galvanized steel, Aluminum.
 - 12. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- E. Jackshaft:
- 1. Size: 0.5-inch diameter min.
 - 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- F. Damper Hardware:
- 1. 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.
 - 2. Include center hole to suit damper operating-rod size.
 - 3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Arrow United Industries.
 - 2. Greenheck Fan Corporation.
 - 3. McGill AirFlow LLC.
 - 4. Nailor Industries Inc.
 - 5. Pottorff.
 - 6. Ruskin Company.
- B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
 - 1. U or Angle shaped.
 - 2. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
 - 3. Mitered and welded corners.
- D. Blades:
 - 1. Multiple blade with maximum blade width of 6 inches.
 - 2. Parallel blade for non modulating application
 - 3. Opposed-blade design for all modulating applications
 - 4. Galvanized-steel, Stainless steel, Aluminum.
 - 5. 0.064 inch thick single skin or 0.0747-inch-thick dual skin.
 - 6. Blade Edging: Closed-cell neoprene.
 - 7. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- E. Blade Axles: 1/2-inch-diameter; galvanized steel, or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - 1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
 - 1. Oil-impregnated bronze, Molded synthetic, Oil-impregnated, stainless-steel sleeve, or Stainless-steel sleeve.
 - 2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

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

2. Greenheck Fan Corporation.
 3. Nailor Industries Inc.
 4. Pottorff.
 5. Ruskin Company.
 6. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades inside airstream for application in duct over 24" in height. Curtain type with blades outside airstream for ducts 24" or less in height. Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.138 inch up to 4 SF 0.39 over 4 SF inch thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- 2.8 CEILING RADIATION DAMPERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aire Technologies.
 2. Nailor Industries Inc.
 3. Pottorff.
 4. Prefco.
 5. Ruskin Company.
- B. General Requirements:
1. Labeled according to UL 555C by an NRTL.

2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
- C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.
- D. Blades: Galvanized sheet steel with refractory insulation.
- E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- F. Fire Rating: 1hr for applications in assemblies up to 1 ½ hr rating. 2hr for application in assemblies of up to 3hr

2.9 SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Greenheck Fan Corporation.
 2. Nailor Industries Inc.
 3. Pottorff.
 4. Ruskin Company.
- B. General Requirements: Label according to UL 555S by an NRTL.
- C. Smoke Detector: Integral, factory wired for single-point connection. Except for NYC smoke detector shall be provided by the fire alarm contractor.
- D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.
- E. Blades: Roll-formed, horizontal, overlapping, 0.063-inch- thick, galvanized sheet steel.
- F. Leakage: Class I.
- G. Rated pressure and velocity to exceed design airflow conditions.
- H. Mounting Sleeve: Factory-installed, 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
- I. Damper Motors: Modulating or two-position action.
- J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling fan control and position indication.
2. Test and reset switches, damper or remote mounted.
3. Manual damper testing by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.
4. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
5. Dual Position Indicator Switch Package: Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
6. Duct Smoke Detector: Factory mounted in the damper sleeve with interconnecting wiring from the damper actuator to the smoke detector enabling a single power connection point for easy field wiring.

2.10 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
 2. Pottorff.
 3. Ruskin Company.
- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 for assemblies up to 2 hour and 3 hr. rating for assemblies over 1 1/2hours.

- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.
- F. Primary heat responsive device set at 285 deg F, resettable.
- G. Secondary heat closure device, set at 350 deg F, resettable.
- H. Smoke Detector: Integral, factory wired for single-point connection.
- I. Blades: Roll-formed, horizontal, interlocking, 0.063-inch- thick, galvanized sheet steel.
- J. Leakage: Class I.
- K. Rated pressure and velocity to exceed design airflow conditions.
- L. Mounting Sleeve: Factory-installed, 0.039-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.
- M. Master control panel for use in dynamic smoke-management systems.
- N. Damper Motors: Modulating or two-position action.
- O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.
- P. Accessories:
 - A. DRS-30 Two-Temperature Fire Closure Device:
 - 1. UL classified two-temperature device permits the damper to be re-opened after initial temperature closure allowing the damper to remain operable for smoke management purposes until the high temperature limit is reached.

2. Manual damper testing is permitted by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.
 3. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
- B. PI-50 Dual Position Indicator Switch Package: Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
- C. Duct Smoke Detector: Factory mounted in the damper sleeve with interconnecting wiring from the damper actuator to the smoke detector enabling a single power connection point for easy field wiring.

2.11 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc.
 3. Hardcast, Inc.
 4. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.12 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Industrial Noise Control, Inc.
 2. McGill AirFlow LLC.
 3. Ruskin Company.
 4. Vibro-Acoustics.
 5. Industrial Acoustics
- B. General Requirements:
1. Factory fabricated.
 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.

3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Shape:
1. Rectangular straight with splitters or baffles.
 2. Round straight with center bodies or pods.
 3. Rectangular elbow with splitters or baffles.
 4. Round elbow with center bodies or pods.
 5. Rectangular transitional with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.040 inch thick.
- E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.
1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
 2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
 3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
 4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.
- F. Inner Casing and Baffles: ASTM A 653/A 653M, G60 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.
- G. Special Construction:
1. Suitable for outdoor use.
 2. High transmission loss to achieve STC 45.
- H. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- I. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 2. Dissipative or Film-lined type with fill material.
 - a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 15 percent compression and Moisture-proof nonfibrous material.
 - b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
 3. Lining: Fiberglass cloth.
- J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed or continuously welded or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:

1. Integral 1-1/2 3-hour fire damper with access door. Access door to be high transmission loss to match silencer.
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow measuring devices.

L. Source Quality Control: Test according to ASTM E 477.

1. Testing to be witnessed by Engineer.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

M. Capacities and Characteristics:

1. Configuration: Straight or 90-degree elbow as indicated on plan
2. Shape: Rectangular or Round as indicated on plan
3. Attenuation Mechanism: Acoustical glass fiber with protective film liner.
4. Maximum Pressure Drop: 0.25-inch wg.
5. Casing:
 - a. Attenuation: Standard.
 - b. Outer Material: Galvanized steel.
 - c. Inner Material: Galvanized steel.
6. Velocity Range: 500 fpm max.
7. End Connection: 1-inch slip joint or Flange.
8. Length: as per plan
9. Face Dimension:
 - a. Width: as per plan
 - b. Height: as per plan
10. Face Velocity: as per plan
11. Dynamic Insertion Loss: as per plan
12. Generated Noise: as per plan
13. Accessories:
 - a. Access door.
 - b. Birdscreen.

2.13 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Duro Dyne Inc.
 - 5. METALAIRE, Inc.
 - 6. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.14 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Company.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Copper or Aluminum.
- D. Cable: Steel.
- E. Wall-Box Mounting: Recessed.
- F. Wall-Box Cover-Plate Material: Stainless steel.

2.15 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc.
 3. Greenheck Fan Corporation.
 4. McGill AirFlow LLC.
 5. Nailor Industries Inc.
 6. Pottorff.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles for plenum applications.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges or Continuous and two compression latches with outside and inside handles.
- C. Pressure Relief Access Door:
1. Door and Frame Material: Galvanized sheet steel.
 2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 4. Factory set at 3.0- to 8.0-inch wg.
 5. Doors close when pressures are within set-point range.
 6. Hinge: Continuous piano.
 7. Latches: Cam.
 8. Seal: Neoprene or foam rubber.
 9. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.16 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M.
 - 2. Ductmate Industries, Inc.
 - 3. Flame Gard, Inc.
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.17 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Duro Dyne Inc.
 - 4. Elgen Manufacturing.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches or 5-3/4 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd.
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.

3. Service Temperature: Minus 50 to plus 250 deg F.
 - G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 1. Minimum Weight: 16 oz./sq. yd.
 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F.
 - H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 1. Minimum Weight: 14 oz./sq. yd.
 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F.
 - I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.
- 2.18 DUCT ACCESSORY HARDWARE
- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
 - B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.
- 2.19 DUCT ROOF SUPPORTS
- A. Ductwork shall be supported a minimum of 12" above the roof with "H" stand manufactured by RTS. Roof support systems. All parts shall be manufactured from hot dipped galvanized steel 1 5/8" channels. All fasteners shall be hot dipped galvanized steel or nickel plated. All channels that are filed cut shall be finished with cold galvanizing at all unfinished edges. All stands shall have two lateral horizontal cross members

- B. "H" stands shall use double base. Gusseted 2"x2" square receiver base plate mounted on 14.5"x17.5" x2" thick neoprene pad model RTSF21G.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install 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. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
 - 3. Install stainless steel volume dampers in stainless steel ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire and smoke dampers according to UL listing.
- H. Install duct security bars. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints and 1/2-inch-diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.
- I. Connect ducts to duct silencers rigidly.
- J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.

4. At drain pans and seals.
 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 7. At each change in direction and at maximum 50-foot spacing and the bottom of all riser in Laundry exhaust ducts.
 8. Upstream from turning vanes.
 9. Upstream or downstream from duct silencers.
 10. Control devices requiring inspection.
 11. Elsewhere as indicated.
- K. Install access doors with swing against duct static pressure.
- L. Access Door Sizes:
1. One-Hand or Inspection Access: 8 by 5 inches.
 2. Two-Hand Access: 12 by 6 inches.
 3. Head and Hand Access: 18 by 10 inches.
 4. Head and Shoulders Access: 21 by 14 inches.
 5. Body Access: 25 by 14 inches.
 6. Body plus Ladder Access: 25 by 17 inches.
- M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- N. Install flexible connectors to connect ducts to equipment.
- O. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- P. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- Q. Connect diffusers or light troffer boots to ducts with maximum 30-inch lengths of flexible duct clamped or strapped in place.
- R. Connect flexible ducts to metal ducts with draw bands.
- S. Install duct test holes where required for testing and balancing purposes.
- T. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.
- U. Install remote volume damper operators for all volume dampers that are concealed and not accessible after finished construction is complete.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Shutoff, single-duct air terminal units.
 - 2. Casing liner.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air terminal units.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Size and location of initial access modules for acoustic tile.
 - 3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Instructions for resetting minimum and maximum air volumes.
 - b. Instructions for adjusting software set points.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufactures:
 - 1. Tittus
 - 2. Anomastat
 - 3. Carnes
 - 4. Greenheck
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.040-inch- thick galvanized steel, single wall.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
 - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections.
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

- D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 6-inch wg inlet static pressure.
 - 2. Damper Position: Normally open.
- F. Attenuator Section: 0.034-inch steel sheet.
 - 1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- H. Control devices shall be by and compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 1. Electronic Damper Actuator: 24 V, powered open, spring return.
 - 2. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit refer to DDC controls specifications.
 - 3. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
 - 4. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 5. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
- I. Controls:
 - 1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.

2. System-powered, wall-mounted thermostat.

2.3 CASING LINER

- A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 1. Minimum Thickness: 1/2 inch.
 2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to AHRI 880.
 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

- A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install air terminal units' level and plumb. Maintain sufficient clearance for normal service and maintenance.
- C. Install wall-mounted thermostats.

3.3 CONNECTIONS

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.
- C. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air terminal unit will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

- #### A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 237416 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components and accessories:

1. Casings.
2. Fans.
3. Motors.
4. Rotary heat exchanger.
5. Coils.
6. Refrigerant circuit components.
7. Air filtration.
8. Supported bag filters.
9. Sound-attenuator section.
10. Dampers.
11. Electrical power connections.
12. Controls.
13. Accessories
14. Roof curbs.
15. Air flow measuring station
16. Variable frequency drive

1.3 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. ECM: Electronically commutated motor.
- C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- D. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

- E. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- F. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.4 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 - 3. Wind- and Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members to which RTUs will be attached.
 - 2. Roof openings.
 - 3. Roof curbs and flashing.
- B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Restraint of internal components, including fans, coils, and refrigeration components.
- D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan Belts: One set(s) for each belt-driven fan.
 2. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 2. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
 3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. AHRI Compliance:

1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
4. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested in accordance with AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

F. UL Compliance: Comply with UL 1995.

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

2.2 MANUFACTURERS

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

1. Carrier Corporation; a unit of United Technologies Corp.
2. Daikin Applied.
3. YORK; a Johnson Controls company.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

1. Design RTU supports to comply with wind and seismic performance requirements.

B. Wind-Restraint Performance:

1. Basic Wind Speed: 79 mph, 103 mph (3 sec peak)
 2. Building Classification Category: I.
 3. Minimum 10 lb/sq. ft multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
- C. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to ASCE 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified" and the unit will be fully operational after the seismic event.

2.4 CASINGS

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Double-Wall Construction: Fill space between walls with 1 1/2 inch foam insulation and seal moisture tight for R-7 performance.
- C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
- D. Inner Casing Fabrication Requirements:
1. Inside Casing: G-90-coated galvanized steel, 0.028 inch thick.
- E. Corrosion-Resistant Coating: Apply a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B 117.
1. Standards:
 - a. ASTM B-117 for salt spray.
 - b. ASTM D-2794 for minimum impact resistance of 100 in-lb
 - c. ASTM B-3359 for cross-hatch adhesion of 5B.
 2. Application: Spray.
 3. Thickness: 1 mil.
 4. Gloss: Minimum of 50 gloss units on a single-angle, 60-degree meter.
 5. UV Protection: Spray-applied topcoat.
- F. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
1. Materials: ASTM C 1071, Type I.
 2. Thickness: 1 1/2 inch.

3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
 4. Liner Adhesive: Comply with ASTM C 916, Type I.
- G. Condensate Drain Pans: Fabricated using stainless 0.025 inches thick steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.
1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
 2. Drain Connections: Threaded nipple.
- H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 FANS

- A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.
1. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.
- B. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.
- C. Relief-Air Fan: Backward inclined, shaft mounted on permanently lubricated motor.
- D. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when fan-mounted frame and RTU-mounted frame are anchored to building structure.

2.6 MOTORS

- A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.
- B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Service Factor: 1.15.
- D. Motor Bearings: 200,000 hrs.
- E. Efficiency: Premium efficient.

2.7 COILS

A. Supply-Air Refrigerant Coil:

1. Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Condensate Drain Pan: Galvanized steel with corrosion-resistant coating OR Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

B. Outdoor-Air Refrigerant Coil:

1. Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

C. Hot-Gas Reheat Refrigerant Coil:

1. Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Suction-discharge bypass valve.

2.8 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: Two minimum

B. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

C. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.

11. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
12. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.9 AIR FILTRATION

- A. Minimum arrestance and a minimum efficiency reporting value according to ASHRAE 52.2.
- B. Flat Panel Pre- Filters:
 1. Description: Factory-fabricated, self-supported, flat, non-pleated, panel-type, disposable air filters with holding frames.
 2. Filter Unit Class: UL 900, Class 1.
 3. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.
 - a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 - b. Media shall be coated with an antimicrobial agent.
 - c. Metal Retainer: Upstream side and downstream side.
- C. Pleated Panel Final Filters:
 1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
 2. Filter Unit Class: UL 900, Class 1.
 3. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.
 - a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 - b. Media shall be coated with an antimicrobial agent.
 - c. Separators shall be bonded to the media to maintain pleat configuration.
 - d. Welded-wire grid shall be on downstream side to maintain pleat.
 - e. Media shall be bonded to frame to prevent air bypass.
 - f. Support members on upstream and downstream sides to maintain pleat spacing.

2.10 SOUND-ATTENUATOR SECTION

- A. Factory-installed section integral with unit with range of splitter thickness and air passages to optimize acoustic performance with minimal air pressure resistance.
- B. Perforated double-wall construction with moisture-resistant coated acoustic fill.

2.11 DAMPERS

- A. Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with motorized damper filter.

- B. Outdoor- and Return-Air Mixing Dampers: Opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.
 - 1. Leakage Rate: As required by ASHRAE/IES 90.1.
 - 2. Damper Motor: Modulating with adjustable minimum position.
 - 3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1, with bird screen and hood.
 - 4. Return air dampers shall be UL555s listed for smoke control. Contractor shall be responsible to have dampers modified by the manufacture or provide field replacements as required.
- C. Barometric relief dampers.

2.12 ELECTRICAL POWER CONNECTIONS

- A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.
- B. Each fan and motor internal to the unit shall have a separate motor starter and disconnect switch by the unit manufacture. The supply fan shall have a variable frequency drive motor starter disconnect switch built into the unit by the manufacture.

2.13 CONTROLS

- A. DDC Controller: factor mounted by manufacture
 - 1. Controller shall have volatile-memory backup.
 - 2. Safety Control Operation:
 - a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
 - b. Fire stats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
 - c. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 283111 "Digital, Addressable Fire-Alarm System" and Section 283112 "Zoned (DC Loop) Fire-Alarm System."
 - d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.
 - e. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
 - 3. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 - 4. Unoccupied Period:

- a. Heating Setback: 10 deg F.
 - b. Cooling Setback: System off.
 - c. Override Operation: Two hours.
5. Supply Fan Operation:
 - a. Occupied Periods: Run fan continuously.
 - b. Unoccupied Periods: Cycle fan to maintain setback temperature.
6. Refrigerant Circuit Operation:
 - a. Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass to match compressor output to cooling load to maintain room or discharge temperature refer to the sequence of operation and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
 - b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
7. Hot-Gas Reheat-Coil Operation:
 - a. Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles compressor.
 - b. Unoccupied Periods: Reheat not required.
8. Fixed Minimum Outdoor-Air Damper Operation:
 - a. Occupied Periods: Open to the percent required to meet min outside air
 - b. Unoccupied Periods: Close the outdoor-air damper.
9. Economizer Outdoor-Air Damper Operation:
 - a. Morning warm up cool down building outdoor air flush cycles.
 - b. Occupied Periods: Open to 10 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F. Use and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
 - c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
 - d. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc or 4 to 20 mA.
10. Carbon Dioxide Sensor Operation:
 - a. Occupied Periods: refer to sequence of operations.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

11. Terminal-Unit Relays:

- a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

B. Interface Requirements for building DDC Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface for central HVAC control workstation for the following:
 - a. Adjusting set points.
 - b. Monitoring supply fan start, stop, and operation.
 - c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
 - d. Monitoring occupied and unoccupied operations.
 - e. Monitoring constant and variable motor loads.
 - f. Monitoring variable-frequency drive operation.
 - g. Monitoring cooling load.
 - h. Monitoring economizer cycles.
 - i. Monitoring air-distribution static pressure and ventilation air volume.

2.14 ACCESSORIES

- A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.
- B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- C. Remote potentiometer to adjust minimum economizer damper position.
- D. Return-air bypass damper.
- E. Factory- or field-installed demand-controlled ventilation.
- F. Safeties:
 1. Smoke detector.
 2. Condensate overflow switch.
 3. Phase-loss reversal protection.
 4. High and low pressure control.
- G. Coil guards of painted, galvanized-steel wire.
- H. Hail guards of galvanized steel, painted to match casing.

- I. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
- J. Door switches to disable heating or reset set point when open.
- K. Outdoor air intake weather hood with moisture eliminator.
- L. Service Lights and Switch: Factory installed in fan section fan and coil sections each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

2.15 SPRING VIBRATION ISOLATION ROOF CURBS

- A. Wind Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with code requirements for wind-load requirements.
- B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C 1071, Type I or II.
 - b. Minimum Thickness: 1-1/2 inches.
 - c. 3 pound per cubic foot density fiberglass insulation.
 - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C 916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C 916, Type I.
- C. Curb Dimensions: Height of 24 inches full length and width of unit.
- D. The lower member shall consist of galvanized steel Z section or channel containing adjustable and removable steel springs that support the upper floating section. The upper frame shall provide continuous support for the equipment and shall be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware must be nickel plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing fastened over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports

with removable waterproof covers. Lower curbs shall have provision for 2" of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc

E. Optional equipment:

1. Sheet metal access doors in front of spring isolators
2. Acoustic package (2) sealed layers of gypsum attached to the floating upper base supported by steel members around the perimeter and across the width of the curb.

2.16 AIR FLOW MONITORING (25-OAF, 75/100 OAF)

- A. Optional airflow monitoring stations will be provided on air inlets, as shown in performance specifications.
- B. Airflow monitoring stations will bear the AMCA Certified Ratings Seal for Airflow Measurement Performance.
- C. Airflow monitoring station dampers will comply with leakage rates per ASHRAE 90.1.
- D. Airflow monitoring stations will be accurate within 5% of actual airflow between 350 FPM and 4000 FPM free area velocity.
- E. Outdoor air intake openings with air flow monitoring stations will have rain louver.
- F. Louver will be a wind-driven rain penetration class A louver.
- G. Louver effectiveness ratio will be 100% at the following conditions:
- H. Wind velocity, 29 mph into louver.
- I. Rain fall rate, 3 in./hr.
- J. Free area air velocity, 1500 FPM.
- K. All VAV units shall be equipped with an outside air volume measurement system similar to Tek-Air. The system shall continuously measure outside air and adjust the outside air damper to maintain the minimum air volume as indicated in the unit schedule.

2.21 STARTERS AND DISCONNECTS

- A. All fan and damper motors shall be furnished with starter and disconnect switches. All VAV units shall be furnished with variable frequency drives.
- B. Starters that are unit mounted may be combination motor starter/disconnect switches. When fan starters are remoted mounted, or installed in a motor control center, provide separate disconnect for all fan motors mounted on the fan section of the air handler. Refer to plans and schedules for starter / disconnect locations

- C. For a complete description of requirements for motor starters and combination starters/disconnects refer to specification section 23 05 13 Common motor requirements for HVAC.
- D. Minimum requirements for starters without disconnect switch.
 - 1. Adjustable motor overload with trip indication.
 - 2. Manual overload reset button (accessible without opening enclosure).
 - 3. 115-v fused secondary control transformer (fuse included — fused primary and secondary over 50 amps).
 - 4. Hand/Off/Auto selector switch (accessible without opening enclosure).
 - 5. Separate 4-position terminal strip for remote H-O-A wiring.
 - 6. C series contactors.
 - 7. Horsepower rated for motor applications.
 - 8. NEMA 4X type non-metallic enclosures.
 - 9. Lug connections for field wiring.
 - 10. Factory mounted, wired, and run tested with factory-supplied motor.
 - 11. UL listed.
- E. Minimum requirements for combination starters / disconnect switch.
 - 1. Non-fused UL 508 disconnect switch with lockable handle (locks not provided).
 - 2. Cover interlock.
 - 3. Adjustable motor overload with trip indication.
 - 4. Manual overload reset button (accessible without opening enclosure).
 - 5. 115-v fused secondary control trans- former (fuse included — fused primary and secondary over 50 amps).
 - 6. Hand/Off/Auto selector switch (accessible without opening enclosure).
 - 7. Separate 4-position terminal strip for remote H-O-A wiring.
 - 8. C series contactors.
 - 9. Horsepower rated for motor applications.
 - 10. NEMA 4X type non-metallic enclosures.
 - 11. Lug connections for field power wiring.
 - 12. Factory mounted, wired, and run tested with factory-supplied motor.
 - 13. UL listed.
- F. For a complete description of requirements for Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."
- G. Minimum requirements for variable-Frequency Motor Controller:
 - 1. Manufactured Units: Pulse-width modulated; variable torque for Design A and Design B inverter-duty motors.
 - 2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
 - 3. Unit Operating Requirements:
 - a. Internal Adjustability:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: 0.1 to 999.9 seconds.

- 4) Deceleration: 0.1 to 999.9 seconds.
 - 5) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - b. Self-Protection and Reliability Features:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Under- and overvoltage trips.
 - 4) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - 5) Critical frequency rejection.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Motor-overtemperature fault.
 - c. Bidirectional auto speed search.
 - d. Torque boost.
 - e. Motor temperature compensation at slow speeds.
 - 1) Panel-mounted operator station.
 - 2) Historical logging information and displays.
 - 3) Digital indicating devices.
 - f. Control Signal Interface: Electric.
 - g. Proportional Integral Directive (PID) control interface.
 - h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.
4. Line Conditioning:
 - a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." AHRI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Equipment Mounting:
 - 1. Install RTUs on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 CONNECTIONS

- A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- B. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination at top of roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
 - 4. Install return-air duct continuously through roof structure.
 - 5. Install normal-weight, 3000-psi, compressive strength (28-day) concrete mix inside roof curb, 4 inches thick. Concrete, formwork, and reinforcement are specified with concrete.
- C. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. RTU will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to compressor, coils, and fans.
 - 3. Inspect internal insulation.
 - 4. Verify that labels are clearly visible.
 - 5. Verify that clearances have been provided for servicing.
 - 6. Verify that controls are connected and operable.
 - 7. Verify that filters are installed.
 - 8. Clean condenser coil and inspect for construction debris.
 - 9. Connect and purge gas line.
 - 10. Remove packing from vibration isolators.
 - 11. Inspect operation of barometric relief dampers.
 - 12. Verify lubrication on fan and motor bearings.
 - 13. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 14. Adjust fan belts to proper alignment and tension.
 - 15. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.

16. Inspect and record performance of interlocks and protective devices; verify sequences.
17. Operate unit for an initial period as recommended or required by manufacturer.
18. Calibrate thermostats.
19. Adjust and inspect high-temperature limits.
20. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
21. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
22. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
23. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
24. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
25. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-temperature limit in ductwork after steam coil.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.
26. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied

conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416

SECTION 237433 - DEDICATED OUTDOOR AIR UNITS (DOAS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Requirements:
 - 1. Section 284621.11 "Addressable Fire-Alarm Systems."

1.2 SUMMARY

- A. Section includes factory-assembled, dedicated outdoor air-handling units, including multiple components, capable of heating and cooling 100 percent outdoor air.

1.3 DEFINITIONS:

- A. ECM: Electronically commutated motor.
- B. IS COP: Integrated Seasonal Coefficient of Performance.
- C. ISMRE: Integrated Seasonal Moisture Removal Efficiency.
- D. MRC: Moisture Removal Capacity.

1.4 ACTION SUBMITTALS

- A. Product Data: For each dedicated outdoor-air unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated.
 - b. Certified fan-sound power ratings.
 - c. Fan construction and accessories.
 - d. Motor ratings, electrical characteristics, and motor accessories.
 - 6. Include certified coil-performance ratings with system operating conditions indicated.

7. Include filters with performance characteristics.
8. Include heat exchangers with performance characteristics.
9. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each dedicated outdoor-air unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittal: For dedicated outdoor-air-unit supports indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators seismic restraints and wind restraints, and for designing vibration isolation bases.
2. Wind Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
3. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor/roof plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates, for dedicated outdoor-air units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Articles a

E. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

1. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.

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

F. Source quality-control reports.

G. Startup service reports.

H. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dedicated outdoor-air units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One sets for each belt-driven fan.
2. Filters: One sets for each unit.
3. Gaskets: One sets for each access door.

1.8 WARRANTY

- A. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Dedicated Outdoor-Air-Handling Units: Three Insert number years from date of Substantial Completion.
 2. Warranty Period for Compressors: Five years from date of Substantial Completion.
 3. Warranty Period for Heat Exchangers: Five years from date of Substantial Completion.
 4. Warranty Period for Rotary Heat Exchangers: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory) and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- D. ASHRAE 15 and ASHRAE 34 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. ASHRAE 84 Compliance: Comply with capacity ratings for heat-wheel energy-recovery equipment.
- G. UL Compliance:
 - 1. Electric Coils: Comply with requirements in UL 1995.
- H. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and wind restraints.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Refer to plans and schedules

2.3 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the basis of design manufacture LG. The following manufactures may be use subject compliance with the contract documents and review and approval by the engineer.
 - 1. AAON.
 - 2. LG
 - 3. Desert Aire.
 - 4. Munters Corporation.
 - 5. Addison
- B. Source Limitations: Obtain dedicated outdoor-air units from single manufacturer.

2.4 UNIT CASING

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Configuration: Horizontal unit with horizontal, bottom discharge for roof-mounting installation.
- C. Double-Wall Configuration:
 - 1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - 2. Inside Casing Wall:
 - a. Inside Casing, All Other Sections: Galvanized steel, solid or perforated.

- b. Antimicrobial Coating: Applied during the manufacturing process. Coating is to be EPA approved, NSF approved, and FDA listed.
- 3. Floor Plate: Reinforced metal surface; reinforced to limit deflection when walked on by service personnel. Insulation is provided below metal walking surface.
- 4. Roof: Standing seam or membrane; sloped to drain water.
- 5. Casing Insulation:
 - a. Materials: Polyurethane foam insulation.
 - b. Casing Panel R-Value: Minimum R-13.
 - c. Insulation Thickness: 2 inches.
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
- D. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- E. Static-Pressure Classifications:
 - 1. For Unit Sections Upstream of Fans: Minus 2 inches wg.
 - 2. For Unit Sections Downstream and Including Fans: 3 inches wg.
- F. Panels and Doors:
 - 1. Panels:
 - a. Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
 - b. Fasteners: Two or more camlock-type fasteners for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components
 - 2. Doors:
 - a. Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
 - b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
 - 3. Locations and Applications:
 - a. Fan Section:
 - b. Access Section: Doors.

- c. Damper Section:
- d. Filter Section: large enough to allow periodic removal and installation of filters.
- e. Relief Section: Doors.

G. Condensate Drain Pans:

- 1. Location: Each refrigerant coil and rotary heat exchanger.
- 2. Construction:
 - a. Single-wall, noncorrosive polymer or stainless steel sheet.
- 3. Size: Large enough to collect condensate from cooling coils, including coil piping connections, coil headers, and return bends.
- 4. Drain Connection:
 - a. Located on one end or both ends of pan, at lowest point of pan.
 - b. Terminated with threaded nipple.
 - c. Minimum Connection Size: NPS 1.
- 5. Slope: Minimum 0.125-inch/ft. slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
- 6. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
- 7. Width: Entire width of water-producing device.
- 8. Depth: A minimum of 2 inches deep.
- 9. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
- 10. Provide units having stacked coils with intermediate drain pan to collect condensate from top coil.

2.5 FANS, DRIVES, AND MOTORS

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Supply-Air Fans and Relief-Air Fans: Centrifugal; galvanized or painted steel; mounted on solid-steel shaft.
 - 1. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway.
 - 2. Shaft Bearings:
 - a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours in accordance with ABMA 9.

3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 4. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
 5. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.
 6. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 7. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
 8. Mounting: For internal vibration isolation. Factory mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
 9. Shaft Lubrication Lines: Extended to a location outside the casing.
 10. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.
 - a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
- C. Drive, Belt: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.25 service factor based on fan motor.
1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 2. Belts: Oil resistant, nonsparking and nonstatic; in matched sets for multiple-belt drives.
 3. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; 0.146 inch thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.
- D. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated motors.

E. Motors:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure Type: Open, drip proof.
4. Enclosure Materials: Cast iron.
5. Motor Bearings: .
6. Unusual Service Conditions:
 - a. Ambient Temperature: 5 deg C.
 - b. Altitude: 1000' above sea level.
7. Efficiency: Premium efficient as defined in NEMA MG 1.
8. NEMA Design:
9. Motor Pulleys: Adjustable pitch for use with 5 hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
10. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
11. Mount unit-mounted disconnect switches on exterior or interior of unit.

F. Variable-Frequency Motor Controller: Serving each fan individually in fan array.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B inverter-duty motors.
2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
3. Unit Operating Requirements:
 - a. Internal Adjustability:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: 0.1 to 999.9 seconds.
 - 4) Deceleration: 0.1 to 999.9 seconds.
 - 5) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - b. Self-Protection and Reliability Features:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Under- and overvoltage trips.
 - 4) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - 5) Critical frequency rejection.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.

- 8) Motor-overtemperature fault.
- c. Bidirectional autospeed search.
- d. Torque boost.
- e. Motor temperature compensation at slow speeds.
- 1) Panel-mounted operator station.
- 2) Historical logging information and displays.
- 3) Digital indicating devices.
- f. Control Signal Interface: Electric.
- g. Proportional Integral Directive (PID) control interface.
- 4. Line Conditioning:
 - a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.
- 5. Bypass Systems:
 - a. Bypass Mode: Manual operation only.
 - b. Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors and isolating switch.

2.6 COILS

A. General Requirements for Coils:

- 1. Comply with AHRI 410.
- 2. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- 3. Coils are not to act as structural component of unit.

B. Supply-Air Refrigerant Coils:

- 1. Tubes: Copper.
- 2. Fins:
 - a. Material: Aluminum.
 - b. Fin Spacing: Maximum 12, 10, or 8 fins per inch.
- 3. Fin and Tube Joints: Mechanical bond.
- 4. Headers: Seamless-copper headers with brazed connections.
- 5. Frames: Galvanized steel.
- 6. Coatings: None.
- 7. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - a. Working Pressure: Minimum 300 psig.

C. Hot-Gas Reheat Refrigerant Coils:

1. Tubes: Copper.
2. Fins:
 - a. Material: Aluminum.
 - b. Fin Spacing: Maximum 12, 10, or 8 Insert spacing fins per inch.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - a. Working Pressure: Minimum 300 psig.
8. Suction-discharge bypass valve.

D. Condenser Refrigerant coils:

1. Tube Material: Copper.
2. Fin Material: Aluminum.
3. Fin and Tube Joint: Mechanical bond.
4. Coating: None.

2.7 REFRIGERATION CIRCUIT COMPONENTS

- A. Compressors: Hermetic, variable-speed scroll compressors, mounted on integral vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- B. Refrigerant: [R-410A].
- C. Refrigeration Specialties:
1. Expansion valve with replaceable thermostatic element.
 2. Refrigerant filter/dryer.
 3. Manual-reset high-pressure safety switch.
 4. Automatic-reset low-pressure safety switch.
 5. Minimum off-time relay.
 6. Automatic-reset compressor motor thermal overload.
 7. Thermostat for coil freeze-up protection during low-ambient-temperature operation or loss of air.
 8. Brass service valves installed in discharge and liquid lines.
 9. Low-ambient kit high-pressure sensor.
 10. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
 11. Modulating hot-gas reheat solenoid valve with a replaceable magnetic coil.

12. Heat-pipe heat exchanger, wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.
13. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification for single-speed compressor.

2.8 AIR FILTRATION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
 1. Description: Flat, non-pleated pre-filters and Pleated factory-fabricated, self-supported disposable air filters with holding frames.
 2. Filter Unit Class: UL 900.
 3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 4. Filter-Media Frame: High wet-strength beverage board with perforated metal retainer, or metal grid, on outlet side.
- C. Mounting Frames:
 1. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
 2. Cartridge filters arranged for flat orientation, removable from access plenum.
 3. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter.

2.9 ROTARY HEAT EXCHANGER

- A. Casing:
 1. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory-painted finish.
 2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
 3. Casing seals on periphery of rotor and on duct divider and purge section.
 4. Support vertical rotor on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearings.
- B. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
- C. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Provide permanently lubricated wheel bearings.
- D. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. Variable-frequency controller, factory mounted and wired, permitting input of 4-20 mA or 1-10 V control signal.
3. Control energy recovery to permit air economizer operation.
 - a. Bypass dampers to assist energy recovery control.
4. Pilot-Light Indicator: Display rotor rotation and speed.
5. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
6. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
7. Defrost cycle.

2.10 DAMPERS

- A. Outdoor- and Relief-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1 inch wg and 8 cfm/sq. ft. at 4 inches wg.
- B. Electronic Damper Operators:
 1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 2. Electronic damper position indicator shall have visual scale indicating percentage of travel and 2 to 10 V dc feedback signal.
 3. Operator Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 4. Non-spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
 6. Size dampers for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

- c. Dampers with 2 to 3 Inches wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
- d. Dampers with 3 to 4 Inches wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
- 7. Coupling: V-bolt and V-shaped, toothed cradle.
- 8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- 9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on non-spring-return actuators.
- 10. Power Requirements (Two-Position Spring Return): 24 V dc.
- 11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
- 12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.
- 13. Temperature Rating: Minus 22 to plus 122 deg F.

2.11 ELECTRICAL POWER CONNECTIONS

- A. Single-Point Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.
- B. Enclosure: NEMA 250, Type 3R, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key.
- C. Wiring: Numbered and color-coded to match wiring diagram.
- D. Wiring Location: Install factory wiring outside an enclosure in a raceway.
- E. Power Interface: Field power interface to be NEMA KS 1, heavy-duty, non--fused disconnect switch.
- F. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:
 - 1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
 - 2. NEMA KS 1, heavy-duty, non-fusible switch.
 - 3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- G. Factory-Mounted, Overcurrent-Protection Service: For each motor.
- H. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- I. Controls: Factory wire unit-mounted controls where indicated.

1. Service Lights: 60watt LED vaporproof luminaire with individual switched junction box located inside, adjacent to each access door and panel.
 - a. Locations: Each section accessed with door or panel.
2. Convenience Outlets: One 20 A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - a. Locations: Fan section.

J. Control Relays: Auxiliary and adjustable time-delay relays.

2.12 CONTROLS

- A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
- B. Control Wiring: Factory wire connection for controls' power supply.
- C. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.
- D. Remote or Unit-Mounted Status Panel:
 1. Cooling/Off/Heating Controls: Control operational mode.
 2. Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.
 3. Status Lights:
 - a. Filter dirty.
 - b. Fan operating.
 - c. Cooling operating.
 - d. Heating operating.
 - e. Smoke alarm.
 - f. General alarm.
 4. Digital Numeric Display:
 - a. Outdoor airflow.
 - b. Supply airflow.
 - c. Outdoor dry-bulb temperature.
 - d. Outdoor dew point temperature.
 - e. Space temperature.
 - f. Supply temperature.
 - g. Space relative humidity.
 - h. Space carbon dioxide level.
- E. Refrigeration System Controls:

1. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air or outdoor-air temperature is less than 60 deg F.
2. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F.
3. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 50 percent.

F. Rotary Heat-Exchanger Control:

1. Sequence with refrigeration system controls and heating controls.
2. For operation of rotary heat exchanger itself, see "Rotary Heat Exchanger" Article.

G. Damper Controls: Space-pressure sensor modulates outdoor- and relief-air dampers to maintain a positive pressure in space at a minimum of 0.05-inch wg with respect to outdoor reference.

H. DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Links shall include the following:

1. Start/stop interface relay and relay to notify DDC temperature-control system alarm condition.
2. Hardware interface or additional sensors for the following:
 - a. Room temperature.
 - b. Discharge-air temperature.
 - c. Refrigeration system operation.

I. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display unit status and alarms.

1. Hardwired Points:
 - a. Monitoring: On-off status, common trouble alarm.
 - b. Control: On-off operation, supply temperature set-point adjustment space humidity set-point adjustment.
2. ASHRAE 135 (BACnet) Modbus communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the DDC system for HVAC.

2.13 ROOF CURBS

A. SPRING VIBRATION ISOLATION ROOF CURBS

- B. Wind Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with code requirements for wind-load requirements.
- C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
- D. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
- E. Materials: ASTM C 1071, Type I or II.
- F. Minimum Thickness: 1-1/2 inches. 3 pound per cubic foot density fiberglass insulation.
- G. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
- H. Liner Adhesive: Comply with ASTM C 916, Type I.
- I. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
- J. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
- K. Liner Adhesive: Comply with ASTM C 916, Type I.
- L. Curb Dimensions: Height of 24 inches full length and width of unit.
- M. The lower member shall consist of galvanized steel Z section or channel containing adjustable and removable steel springs that support the upper floating section. The upper frame shall provide continuous support for the equipment and shall be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware must be nickel plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing fastened over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc
 1. Optional equipment.
 2. Sheet metal access doors in front of spring isolators
 3. Acoustic package (2) sealed layers of gypsum attached to the floating upper base supported by steel members around the perimeter and across the width of the curb.
- N. Curb Dimensions: Height of 24 inches. Provide adaptable horizontal dimensions as required for existing roof openings.

- O. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

2.14 INTAKE AND RELIEF OPENINGS

- A. Type: Manufacturer's standard hood or louver, including moisture eliminator, at all unit intake and relief openings.
- B. Materials: Match material and finish of casing exterior.
- C. Bird Screen: Comply with requirements in ASHRAE 62.1.
- D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.15 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: ASTM B209.
- E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

2.16 SOURCE QUALITY CONTROL

- A. AHRI 920: Manufacturer to certify that performance ratings are in accordance with AHRI 920 if AHRI 920 certification program is not in place. Provide AHRI 920 certification if AHRI 920 certification program is in place.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label unit fan sound ratings in accordance with AHRI 260 or AMCA 311.
- C. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency.
 - 1. Fan Aerodynamic Performance Rating: Test and rate fan performance in accordance with AMCA 210 or 211

- D. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- E. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- F. Damper Leakage and Air
- G. Performance:
 - 1. Damper Rating: Test and rate dampers for leakage and air performance in accordance with AMCA 510 or AMCA 511
- H. Water Coils: Factory tested to 300 psig in accordance with AHRI 410 and ASHRAE 33.
- I. Refrigerant Coils: Factory tested to minimum 300 psig internal pressure and to minimum 300 psig internal pressure while under water, in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Roof Curb: Install on roof structure or concrete base, level and secure, in accordance with NRCA's "The NRCA Roofing Manual: Membrane Roof Systems" <Insert reference document>. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of curbs with actual equipment provided.
- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

- D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- G. Install separate devices furnished by manufacturer and not factory installed.
- H. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to units, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- E. Duct Connections:
 - 1. Comply with requirements in Section 233113 "Metal Ducts."
 - 2. Drawings indicate the general arrangement of ducts.
 - 3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
 3. Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:
 - a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
 - b. Cooling coil entering-air, dry- and wet-bulb temperatures.
 - c. Condenser coil entering-air dry-bulb temperature.
 - d. Condenser coil leaving-air dry-bulb temperature.
 4. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
 5. Inspect casing insulation for integrity, moisture content, and adhesion.
 6. Verify that clearances have been provided for servicing.
 7. Verify that controls are connected and operable.
 8. Verify that filters are installed.
 9. Clean coils and inspect for construction debris.
 10. Inspect operation of power vents.
 11. Purge gas line.
 12. Inspect and adjust vibration isolators and seismic restraints.
 13. Verify bearing lubrication.
 14. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 15. Adjust fan belts to proper alignment and tension.
 16. Start unit.
 17. Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.

18. Operate unit for run-in period.
19. Calibrate controls.
20. Adjust and inspect high-temperature limits.
21. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
22. Verify operational sequence of controls.
23. Measure and record the following airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Relief-air flow.
 - c. Outdoor-air flow.

- B. After startup, change filters, verify bearing lubrication, and adjust belt tension.
- C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.
- D. Prepare written report of the results of startup services.

3.7 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 237433

SECTION 238129 – VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
 - 1. Indoor, concealed, ceiling and floor mounted units for ducting.
 - 2. Indoor, exposed, floor and wall mounted units.
 - 3. Indoor, recessed, ceiling-mounted units.
 - 4. Indoor, dedicated outdoor air ventilation units.
 - 5. Indoor, energy recovery ventilator.
 - 6. Outdoor, air-source heat recovery units.
 - 7. Heat recovery control units.
 - 8. System controls.
 - 9. System refrigerant and oil.
 - 10. System condensate drain piping.
 - 11. System refrigerant piping.
 - 12. Metal hangers and supports.
 - 13. Metal framing systems.
 - 14. Fastener systems.
 - 15. Miscellaneous support materials.
 - 16. Piping and tubing insulation.
 - 17. System control cable and raceways.
 - 18. Materials
 - 19. Source quality controls
 - 20. Vibration isolation.

1.3 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

- D. HRU: Heat Recovery Unit. HRUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRUs. One liquid line and refrigerant vapor line connect HRUs to associated indoor units.
- H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HCUs. One refrigerant liquid line and refrigerant vapor line connect HCUs to associated indoor units. HCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high- and low-pressure refrigerant between indoor units.
- I. VRF: Variable refrigerant flow.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units and for HRUs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
 - 4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
 - 5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit and HRU control.
 - 6. Include description of control software features.
 - 7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
 - 8. Include refrigerant type and data sheets showing compliance with requirements indicated.
 - 9. For system design software.
 - 10. Indicate location and type of service access.
- B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting and attachment details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
 5. Include diagrams for power, signal, and control wiring.
- C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.
1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
 2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
 3. Size and location of initial access modules for acoustical tile.
 4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
 5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
 6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Service access panels.
 - f. Fire alarm devices
- B. Qualification Data:
1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - a. Retain copies of Installer certificates on-site and make available on request.

2. For VRF HVAC system manufacturer.
 3. For VRF HVAC system provider.
- C. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranties: For manufacturer's warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters:
 - a. One set(s) for each unit with replaceable filters.
 - b. One set(s) for each unit type and unique size of washable filters.
 2. Indoor Units: One for each unique size and type installed.
 3. Controllers for Indoor Units: One for each unique controller type installed.
 4. Insert maintenance material requirements.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Nationally recognized manufacturer of VRF HVAC systems and products.
 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
 3. VRF HVAC systems and products that have been successfully tested and in use on at least five completed projects.
 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.

5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.
- B. Factory-Authorized Service Representative Qualifications:
 1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
 2. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 3. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.
 4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 5. Service and maintenance staff assigned to support Project during warranty period.
 6. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
- C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.
 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 2. Installer certification shall be valid and current for duration of Project.
 3. Retain copies of Installer certificates on-site and make available on request.
 4. Each person assigned to Project shall have demonstrated past experience.
 - a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.
- D. Mockups: Build mockups to set quality standards for materials and execution.
 1. Build mockups to show a finished installation for each of the following applications:
 - a. For each different indoor unit type with exposed surfaces viewable by occupants.
 - b. One typical ceiling cassette unit

2. Mockups need to be operational to test controls and sound.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- E. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 - d. .
 2. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.

- c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: the basis of design shall be LG Electronics. Other manufactures that may be acceptable, subject to compliance with requirements of the contract documents, and review and approval by the engineer.
1. Carrier Corporation /Toshiba.
 2. Daikin AC (Americas), Inc.
 3. Samsung HVAC.
- B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:
1. Indoor and outdoor units, including accessories.
 2. Controls and software.
 3. HRUs.
 4. Refrigerant isolation valves.
 5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

- A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
1. Three-pipe system design.
 2. System(s) operation, heat recovery as indicated on Drawings.
 3. Each system with one refrigerant circuit shared by all indoor units connected to system.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.
- D. ASHRAE Compliance:
1. ASHRAE 15: For safety code for mechanical refrigeration.
 2. ASHRAE 62.1: For indoor air quality.
 3. ASHRAE 135: For control network protocol with remote communication.
 4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

- E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer or specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units, HRUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
 - b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
 - c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.
 - c. Product selection.
 - d. Sizing.

- B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.

5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. Isolation of Equipment: Provide isolation valves to isolate each HRU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

E. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than 60 percent.
2. Not more than 130 percent.
3. Range acceptable to manufacturer.

F. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

G. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

H. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7.
 - b. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: See Drawings.

I. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

J. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, CONCEALED, HORIZONTAL OR VERTICAL UNITS FOR DUCTING

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: 22-gauge Pre-Coated Metal Galvanized or painted steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
6. The inside surface of fan assembly door access panel shall be treated with 1/2 inch polystyrene fiber insulation, encapsulated on both sides.
7. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Unit shall have minimum two to three row coil, 18 fins per inch.
5. Unit shall have a factory supplied condensate drain pan below the coil constructed of HIPS (high impact polystyrene resin).
6. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
7. Unit Internal Tubing: Copper tubing with brazed joints.
8. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
9. Field Piping Connections: Manufacturer's standard.
10. Factory Charge: Dehydrated air or nitrogen.
11. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of HIPS (high impact polystyrene resin).
5. The unit shall have a secondary drain port plug for overflow.

E. Fan and Motor Assembly:

1. Fan(s):
 - a. Direct-drive arrangement.

- b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
 - d. Wheels statically and dynamically balanced.
2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.
6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of three pre-programmed fan speeds. Each setting is also adjustable by field setting to compensate for a limited amount of additional resistance to airflow by adjusting the RPM of the fan motor.
7. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
8. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
9. Each of the settings can be field adjusted from the factory setting (RPM/ESP).
10. Unit shall be designed for high-speed air volume against an external static pressure of up to 1.0" water gauge model dependent.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. The filter access shall be from the front of the unit without removing coil or fan area access panel.
3. The filter access door shall be fitted with thumb screws that can be removed without the use of any tool.
4. Efficiency: ASHRAE 52.2, MERV 11.
5. Media:
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Microprocessor Control
 - a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted controller. The unit shall have a factory mounted return air thermistor for use as a space temperature control device. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode
 - b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted, and shielded communication cable.
 - c. The unit controls shall operate the indoor unit using one of the five operating modes:
 - 1) Auto changeover (Heat Recovery System only)
 - 2) Heating
 - 3) Cooling
 - 4) Dry
 - 5) Fan only
 - d. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
 - e. The unit shall be able to operate with the fan turned off during system cooling thermal off.
 - f. The unit shall be able to operate with a continuous fan setting.
 - g. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
 - h. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable zone controller.
4. Factory-Installed Sensors:
 - a. Unit inlet air temperature.
 - b. Coil entering refrigerant temperature.
 - c. Coil leaving refrigerant temperature.
5. Field-Customizable I/O Capability:
 - a. Analog Inputs: Four for use in customizable control strategies.
 - b. Digital Inputs: Four for use in customizable control strategies.
 - c. Digital Outputs: Four for use in customizable control strategies.
6. Features and Functions:
 - a. Self-diagnostics.
 - b. Time delay.
 - c. Auto-restart.

- d. External static pressure control.
 - e. Auto operation mode.
 - f. Manual operation mode.
 - g. Filter service notification.
 - h. Power consumption display.
 - i. Drain assembly high water level safety shutdown and notification.
 - j. Run test switch.
7. Communication: Network communication with other indoor and outdoor units.
 8. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 9. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 10. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS-485 daisy chain.
- I. Unit Electrical:
1. Enclosure: Metal, suitable for indoor locations.
 2. Field Connection: Single point connection to power unit and integral controls.
 3. Disconnecting Means: Factory-mounted circuit breaker or switch.
 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 6. Raceways: Enclose line voltage wiring in raceways.

2.5 INDOOR, EXPOSED, FLOOR and WALL MOUNTED UNITS

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
1. Unit shall be factory assembled, wired, piped and run tested.
 2. Unit shall be designed to be installed for indoor application.
 3. The unit shall be designed to be free standing on the floor against a wall with factory supplied enclosure or may be located within a field provided architectural enclosure
 4. The back plate of the unit shall have two side mounting flanges with bolt holes to allow a secure attachment of the unit to a vertical surface at or above the floor
 5. The discharge shall be vertical from the top of the unit.
 6. The return air shall be from the bottom front through a toe slot at floor level.
 7. The discharge air opening shall be covered with an architectural grille for units supplied with factory enclosure
 8. Floor standing indoor units without enclosure shall be installed under a field supplied and installed enclosure that does not introduce any significant external static pressure.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
5. The cold surface shall be covered with a coated polystyrene insulating material.
6. The unit shall have a flip open controller access door that shall cover the control mounting bays located on both ends of the top panel.
7. The unit shall have a polymeric resin coated metal safety grille provided behind the removable filters.
8. Unit shall have one supply air outlet and one return air inlet at the toe slot at the floor level.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.
10. Unit shall have minimum of a two-row coil, 19 fins per inch.
11. The coil shall be factory pressure tested at a minimum of 550 psig.
12. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.
 - a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
3. Field Piping Connection: Non-ferrous material with threaded NPT.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).

E. Fan and Motor Assembly:

1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.
 - d. Statically and dynamically balanced.
2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.
6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of three pre-programed fan speeds in the heating mode and fan only mode and four speeds in the cooling mode. The fan speed algorithm provides a field selectable fixed speed.
7. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
8. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
9. Unit shall be designed for high-speed air volume against an external static pressure of up to 0.08" water gauge (uncased).

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: MERV 11
3. The unit shall have access to the filter media through toe slot located on the front of unit without the need to remove any panels.
4. The filters shall be accessible without removing the unit panel.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top of unit cabinet.

H. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Microprocessor Control
 - a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted controller. The unit shall have a factory mounted return air thermistor for use as a space temperature control device. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode
 - b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted, and shielded communication cable.
 - c. The unit controls shall operate the indoor unit using one of the five operating modes:
 - d. Auto changeover (Heat Recovery System only)
 - e. Heating
 - f. Cooling
 - g. Dry
 - h. Fan only
 - i. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
 - j. The unit shall be able to operate with the fan turned off during system cooling thermal off.
 - k. The unit shall be able to operate with a continuous fan setting.
 - l. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
 - m. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable zone controller.
4. Factory-Installed Sensors:
 - a. Unit inlet air temperature.
 - b. Coil entering refrigerant temperature.
 - c. Coil leaving refrigerant temperature.
5. Field-Customizable I/O Capability:
 - a. Analog Inputs: Four for use in customizable control strategies.
 - b. Digital Inputs: Insert number for use in customizable control strategies.
 - c. Digital Outputs: Four for use in customizable control strategies.
6. Features and Functions:
 - a. Self-diagnostics.
 - b. Time delay.
 - c. Auto-restart.

- d. External static pressure control.
 - e. Auto operation mode.
 - f. Manual operation mode.
 - g. Filter service notification
 - h. Power consumption display.
 - i. Drain assembly high water level safety shutdown and notification.
 - j. Run test switch.
7. Communication: Network communication with other indoor units and outdoor unit(s).
 8. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 9. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways.

2.6 INDOOR, RECESSED, CEILING-MOUNTED UNITS (CEILING CASSETTES)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

1. Unit shall be designed to mount recessed in the ceiling and has a surface mounted grille on the bottom of the unit.
2. The unit shall be available in both nominal 2' x 2' and 3' x 3' chassis.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
5. The unit panel shall be provided with an off-white or black Acrylonitrile Butadiene Styrene (ABS) polymeric resin grille.
6. The grille shall have a tapered trim edge, and a hinged, spring clip (screw-less) return air filter-grille door.

7. Unit shall be provided with metal ears designed to support the unit weight on four corners.
8. Ears shall have pre-punched holes designed to accept field supplied all thread rod hangers.
9. Unit shall be supplied with snap off access panels to facilitate leveling of unit without removing the grille.
10. Unit shall have four supply air outlets and one return air inlet.
11. The supply air outlet shall be through four directional slot diffusers each equipped with independent oscillating motorized guide vanes designed to change the airflow direction.
12. The grille shall have a discharge range of motion of 40° in an up/down direction with capabilities of locking the vanes.
13. The unit shall have a guide vane algorithm designed to sequentially change the predominant discharge airflow direction in counterclockwise pattern.
14. Guide vanes shall provide airflow in all directions.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Unit shall have a minimum one or two row coil, 18-19 fins per inch.
- 5.
6. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
7. Internal Tubing: Copper tubing with brazed joints.
8. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
9. Field Piping Connections: Manufacturer's standard.
10. Factory Charge: Dehydrated air or nitrogen.
11. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).
- 5.

E. Fan and Motor Assembly:

1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.

- c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d. Wheels statically and dynamically balanced.
- 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
- 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
- 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
- 5. Vibration Control: Integral isolation to dampen vibration transmission.
- 6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of four pre-programed fan speeds in the heating mode and fan only mode and five speeds in the cooling mode. The fan speed algorithm provides a field selectable fixed speed.
- 7. A field setting shall be provided to vary air throw pattern to compensate for high ceiling installations.
- 8. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Super high, Power Cool, and Auto.
- 9. In heating mode, the indoor fan shall have the following settings: Low, Med, High, Super high and Auto.
- 10. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow

F. Filter Assembly:

- 1. Access: Bottom, to accommodate filter replacement without the need for tools.
- 2. Efficiency: ASHRAE 52.2, MERV 10.
- 3. Media:
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
- 4. The filter access shall be from the bottom of the unit without the need for tools.
- 5. The nominal 3'x3' cabinet unit shall have provision for an optional auto-elevating grille kit designed to provide motorized ascent/descent of the return air grille/pre filter assembly.
- 6. The ascent/descent of the return air grille shall be up to a distance of 14-3/4 feet allowing access to remove and clean the filter.
- 7. The auto-elevating grille shall have a control algorithm to accept up, down and stop control commands from the controller.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

- 1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.
 - a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.

- b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
 - 2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
 - 3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.
- H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.
- I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
- J. Unit Accessories:
 - 1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.
 - 2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
- K. Unit Controls:
 - 1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2. Factory-Installed Controller: Configurable digital control.
 - 3. Microprocessor Control
 - a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
 - b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted and shielded communication cable.
 - c. The unit controls shall operate the indoor unit using one of the five operating modes:
 - d. Auto changeover (Heat Recovery System only)
 - e. Heating
 - f. Cooling
 - g. Dry
 - h. Fan only
 - i. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
 - j. The unit shall be able to operate with the fan turned off during system cooling thermal off.
 - k. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
 - l. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.

- m. Unit shall have a field settable method to choose auto fan speed change operation based on mode of operation, on/off fan operation based on mode of operation, or continuous minimum set fan speed operation.
- 4. Factory-Installed Sensors: Unit inlet air temperature Coil entering refrigerant temperature Coil leaving refrigerant temperature.
- 5. Field-Customizable I/O Capability:
 - a. Analog Inputs: Four for use in customizable control strategies.
 - b. Digital Inputs: Four for use in customizable control strategies.
 - c. Digital Outputs: Four for use in customizable control strategies.
- 6. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control, auto operation mode , manual operation mode , filter service notification , power consumption display , drain assembly high water level safety shutdown and notification , run test switch.
- 7. Communication: Network communication with other indoor units and outdoor unit(s).
- 8. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 9. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:

- 1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
- 2. Field Connection: Single point connection to power entire unit and integral controls.
- 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
- 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
- 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.7 INDOOR, DEDICATED OUTDOOR AIR VENTILATION UNITS

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
 - 1. Specially designed for up to 100 percent outdoor air entering unit.
 - 2. All OAU indoor unit coils shall pressure tested with dry nitrogen to a minimum of 500 psi in the field, coils and indoor units containing coils not rated for 500 psi or more shall not be permitted.

B. Cabinet:

1. Material: Galvanized or painted steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. The cold surfaces of the unit shall be covered externally with sheet insulation made of Ethylene Propylene Diene Monomer (M-Class) (EPDM)
4. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.
5. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
6. Mounting: Manufacturer-designed provisions for field installation.
7. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.
10. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

D. DX Coil Assembly for Reheat Applications: Provide units with a reheat coil where indicated on Drawings.

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Unit shall have a minimum two to three row coil, 19-21 fins per inch.
4. Coil Tubes: Copper, of diameter and thickness required by performance.
5. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
6. Unit Internal Tubing: Copper tubing with brazed joints.
7. Unit Internal Tubing Insulation: Manufacturer's standard insulation.
8. Field Piping Connections: Manufacturer's standard.
9. Factory Charge: Dehydrated air or nitrogen.
10. Testing: Factory pressure tested and verified to be without leaks.

11. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
 12. The coil shall be factory pressure tested at a minimum of 550 psig.
 - 13.
- E. Drain Assembly:
1. Pan: Non-ferrous material, with bottom sloped to low point drain connection. Unit shall have a factory supplied condensate drain pan below the coil constructed of HIPS (high impact polystyrene resin).
 2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet capable of providing minimum 27.5 inch lift from bottom surface of the unit. The unit drain pan is supplied with a secondary drain port/plug allowing the pan to be gravity drained and serviced.
 - 3.
 4. Field Piping Connection: Non-ferrous material with threaded NPT.
- F. Fan and Motor Assembly:
1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d. Wheels statically and dynamically balanced.
 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of three pre-programed fan speeds, each setting is also adjustable by field setting to compensate for a limited amount of additional resistance to airflow by adjusting the RPM of the fan motor.
 6. Vibration Control: Integral isolation to dampen vibration transmission.
- G. Filter Assembly:
1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 13.
 3. Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 4. The filter access shall be from the rear of the unit.

H. Unit Accessories:

1. Motorized Inlet Damper Kit: Low-leakage damper with spring return electric actuator to fail closed on loss of power. Damper controlled by unit to open when unit is operating and close when unit off.

I. Unit Controls:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Microprocessor Control:
 - a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted controller. The unit shall have a factory mounted entering air and discharge air thermistor for use as discharge air control. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode.
 - b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted, and shielded communication cable.
 - c. The unit controls shall operate the indoor unit using one of the four operating modes:
 - d. Auto
 - e. Heating
 - f. Cooling
 - g. Fan only
 - h. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
 - i. The unit shall be able to shut off the fan when entering air temperature falls below 23F
 - j. The unit shall operate with a continuous fan setting.
3. Factory-Installed Controller: Configurable digital control.
4. Factory-Installed Sensors: Coil entering refrigerant temperature Coil leaving refrigerant temperature Unit entering-air temperature Unit leaving-air temperature Unit entering-air relative humidity Unit leaving-air relative humidity.
5. Field-Customizable I/O Capability:
 - a. Analog Inputs: Four for use in customizable control strategies.
 - b. Digital Inputs: Four for use in customizable control strategies.
 - c. Digital Outputs: Four for use in customizable control strategies.
6. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control, auto operation mode, manual operation mode , filter service notification , power consumption display , drain assembly high water level safety shutdown and notification , run test switch.
7. Communication: Network communication with other indoor units and outdoor unit(s).
8. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

9. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.8 INDOOR, ENERGY RECOVERY UNIT

- A. Description: Factory-assembled and -tested complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
6. Unit shall be capable of following operating between 14°F and 113°F ambient temperature.
7. The ERV unit shall have
 - a. interlock capability to indoor unit
 - b. auto restart function
8. Unit shall have an internally mounted control circuit board to communicate with other indoor units and to the outdoor unit.
- 9.

C. Damper Assemblies:

1. Outdoor Air Intake and Exhaust Air Discharge:
 - a. Low-leakage damper with spring return electric actuator to fail closed on loss of power.
 - b. Damper controlled by unit to open when unit is operating and close when unit off.

2. Energy Recovery Heat-Exchanger Bypass:
 - a. Low leakage damper with electric actuator with integral controls to bypass outdoor air around the energy recovery heat exchanger during times of favorable weather, and there is no energy-saving benefit to circulate air across the energy recovery heat exchanger.
- D. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.
 1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - c. Wheels statically and dynamically balanced.
 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
 6. Vibration Control: Integral isolation to dampen vibration transmission.
- E. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.
 1. Access: To accommodate filter replacement without the need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 10.
 3. Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 4. The filter access shall be from the bottom of the unit.
- F. Energy Recovery Heat Exchanger:
 1. Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.
 2. Fixed element with no moving parts.
 3. AHRI 1060 certified and bearing the AHRI label.
- G. Cross Flow Air-to-Air heat exchanger
 1. The heat exchanger shall be constructed of non-flammable, specially processed paper to allow transfer of heat and humidity.
 2. The heat exchanger shall recover energy from indoor air as the air is exhausted outdoors.

3. The recovered energy shall be transferred to the in-coming outdoor air without mixing airstreams.
4. Unit shall have an access panel with a retainer on one side and a hinge on the other to remove air to air cross flow heat exchanger.
5. The air-to-air cross flow heat exchanger shall be able to slide between guides provided on either side inside the unit.
6. The air-to-air cross flow heat exchanger shall be assembled with no moving parts.
7. The supply air passage and exhaust air passage shall be arranged to prevent mixing of airstreams

H. Unit Accessories:

1. Electric Duct Preheater:
 - a. Heater operation interlocked with energy recovery ventilator unit.
 - b. Heater with integral controls to control outdoor air temperature entering energy recovery ventilator unit to a temperature set-point determined by energy recovery ventilator unit manufacturer.
 - c. Listed and labeled.

I. Unit Controls:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Microprocessor Control
 - a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
 - b. The unit shall be capable of independent operation with a wall controller or interlocked to Multi V system.
 - c. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, 2 core, stranded and shielded communication cable.
 - d. The Microprocessor control shall provide following functions:
 - e. Auto restart following power restoration
 - f. External Static Pressure (ESP) control of fans
 - g. ERV mode allowing air to pass through air-to-air heat exchanger
3. Factory-Installed Controller: Configurable digital control.
4. Factory-Installed Sensors:
 - a. Unit entering outdoor air temperature.
 - b. Unit leaving supply air temperature.
 - c. Unit entering exhaust air temperature.
 - d. Unit leaving exhaust air temperature.
 - e. Unit entering outdoor air relative humidity.
 - f. Unit leaving supply air relative humidity.
 - g. Unit entering exhaust air relative humidity.
 - h. Unit leaving exhaust air relative humidity.
5. Field-Customizable I/O Capability:

- a. Analog Inputs: Four for use in customizable control strategies.
 - b. Digital Inputs: Four for use in customizable control strategies.
 - c. Digital Outputs: Four for use in customizable control strategies.
6. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control, local auto operation mode , auto operation through remote signal , manual operation mode , filter service notification , power consumption display , run test switch
 7. Communication: Network communication with other indoor units and outdoor unit(s).
 8. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 9. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.9 OUTDOOR, AIR-SOURCE HEAT RECOVERY (CONDENSING) UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.
4. Heat recovery system shall require three pipes between the outdoor unit and the heat recovery unit and two pipes between the heat recovery unit and each indoor unit to support simultaneous heating and cooling. Between the outdoor unit and heat recovery unit, one pipe shall support bidirectional flow single state liquid refrigerant. The second pipe shall deliver flow of low pressure, low temperature refrigerant gas from the heat recovery unit to outdoor unit. The third pipe shall deliver single state, super-heated, refrigerant hot gas during simultaneous and 100% heating operations from the outdoor unit to heat recovery unit. Heat Recovery systems using two pipes that deliver mixed state (hot gas and liquid) with separation occurring in heat recovery unit shall not be accepted.

5. Heat pump and Heat recovery outdoor units shall be designed to communicate directly with all VRF indoor units manufactured by the same supplier over a field supplied stranded, twisted and shielded pair wire. Systems requiring intermediary protocol translators, signal boosters, integration with a third party building management systems (BMS) or any other device required for communication possible shall not be accepted.

B. Operating Conditions

- a. The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range. Submittal or technical performance data that indicates the required operating ambient range includes data points that do not guarantee continuous compressor operation, noted or footnoted as reference data, shall not be accepted. The required ambient operating range is defined as follows:
- b. Cooling:
 - 1) Heat Pump & Heat recovery System: With optional low ambient kit from -9.9°F DB to 122°F DB
- c. Heating:
 - 1) Heat Recovery: -13°F WB to 61°F WB
- d. Heat Recovery Synchronous (Simultaneous heating and cooling)
 - 1) Cooling based: 14°F DB to 81°F
 - 2) Heating-based: 14°F WB to 61°F WB

C. General Features

1. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor, controls, contacts, relay(s), fan(s), power and communication wiring.
2. All outdoor units, regardless of the Heat Pump or Heat Recovery models, shall be the same generation and provide with most up to date firmware version at the time of delivery. Manufacturers commissioning agents shall assure the owner in the commissioning report that the latest software version.
3. If the specifications include both heat pump and heat recovery outdoor models, the manufacturer shall provide the most recent generation equipment only. Old stock or obsolete models will not be accepted. Products purchased over the internet and not from the manufacturer's authorized local mechanical representative or authorized distributor will not be accepted.
4. The outdoor unit refrigeration circuit at a minimum shall include the following components:
 - a. Refrigerant strainer(s)
 - b. Check valve(s)
 - c. Inverter driven, high pressure shell compressor
 - d. Oil separator
 - e. Accumulator/receiver
 - f. 4-way reversing valve
 - g. Electronic expansion valve(s)
 - h. Double spiral tube sub-cooler and EEV
 - i. High/low Schrader valve service ports with caps
 - j. High/low service valves
 - k. Threaded fusible plug
 - l. High pressure switch

5. The VRF outdoor unit shall use the sub-cooler while operating in cooling mode to sub-cool liquid refrigerant coming from the condenser coil well below saturation temperature to ensure that refrigerant remains in 100% liquid state when it reaches the farthest indoor unit's EEV valve. The amount of sub-cooling shall be modified by the microprocessor controller and minimized at all times to maximize efficiency by not overcooling the liquid.
6. Third Party Controls platform Integration
 - a. The VRF system manufacturer's central controls platform shall be able to communicate with third party building management systems (BMS) via BACnet IP, Modbus TCP, or LonWorks™ protocol allowing third party BMS system control and/or monitoring of the LG air conditioning and heating system. See controls specification for more detailed description of integration and points to be controlled and monitored.
 - b. The VRF system manufacturer shall have available off-the shelf devices that allows on/off binary interfaces between third party ancillary devices such as fans, door locks, photo eyes, key card switches, motion sensors, exhaust fans, dampers, and a single (or group of) VRF indoor units. Indoor units shall have the ability to start/stop the third party device, receive a contact closure signal from the third party device, or have the third party device change the operating conditions of the VRF indoor unit. Operating conditions shall include one or more of the following indoor unit functions: fan speed, fan on/off, thermal on/off cooling or heating, or indoor unit start/stop.
7. Wi-Fi communication:
 - a. The outdoor unit shall be Wi-Fi-capable. Wi-Fi shall allow service or maintenance personal access to the operating system diagnostics and monitoring functions, via the manufacturer's provided maintenance and diagnostic software over a mobile device or personal computer. Communication between devices shall include: 1) Real-time system operation monitoring with the ability to capture all system operating data for a field determined period of time into a downloadable csv file format to a wireless connected device; 2) Collection of point in time (snapshot) information including all current outdoor unit operating conditions and each indoor unit, system EEV and solenoid valves, sensors, compressor speed, and refrigerant operating pressures. Systems that require computers with a hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.
8. Microprocessor Control
 - a) Factory installed microprocessor control in the outdoor unit, heat recovery unit(s), and indoor unit(s) shall communicate using the same protocol. Translators of any kind are not allowed. Communication between VRF system components shall be via field supplied stranded, shielded and twisted wire pair in a RS 485 network configuration. Integrated control system shall perform functions to optimize the operation of the VRF system.
 - b) Power and communication interruption: The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

- c) Main microprocessor shall include human interface capability that provides a visual code that reports systems operation status. If any malfunction occurs, or system is operating with an unstable refrigerant cycle sensors shall report the malfunction to the visual display.
 - d) Main processor shall provide the commissioning agent the ability to customize the VRF systems operation based on the environment in which it is installed. Customization function to include defrost operation, modifying target superheat, sub-cooling, low pressure and high pressure values, and invoke other algorithms such as smart load control to optimize system operating efficiency.
9. Outdoor unit microprocessor shall have the capability of reporting malfunction and diagnostic codes to remote control devices such as the VRF manufacturer's central controller, Zone controllers, and Building Management System (BMS).
10. Refrigerant Flow Control
- a. The refrigerant cycle operation core logic shall establish and maintain target evaporating temperature (T_e) to be constant in cooling mode and condensing temperature (T_c) constant in heating mode and maintain system stable operation while operating compressors across the range of environmental conditions guaranteeing continuous compressor operation. VRF system core logic shall be able to dynamically modify the target evaporator and condenser temperatures to maximize energy savings when system is operating at part load conditions.
 - b. Smart Load Control (SLC): Smart load control operation shall enhance energy savings and increase indoor comfort by monitoring the real time ambient temperature, real time weighted mean average building load, and the outdoor relative humidity (if enabled).
 - 1) Smart load control shall be field selectable to optimize system operation for project location and building use. Smart Load Control field setting shall select one of three operating algorithms. The commissioning agent shall select at the time of commissioning and can be changed at any other time:
 - 2) The Smart Load Control available settings shall:
 - a) The system shall be influenced by any one of the chosen algorithm
 - b) Off mode: Smart load control algorithm shall be in off mode
 - c) Smooth mode: Smart Load control shall maximize energy savings. The rate of temperature change shall be insignificant.
 - d) Normal Mode: Smart Load Control shall balance the rate of temperature change with energy consumed.
 - e) Peak Mode: Smart Load shall quickly cool/heat the building. The energy consumption shall not be the priority in this mode.
 - 3) For the first 20 minutes after the initial startup, the Smart Load Control will influence the outdoor unit operation for the chosen algorithm. This operation will be available at every start up.
 - 4) After 20 minutes of compressor operation
 - a) Smart Load control will maintain the chosen logic and system will operate with the same core logic.
 - 5) Smart Load Control monitors two or three inputs:
 - a) Weighted mean average building load

- b) Outdoor ambient dry bulb temperature
 - c) Outdoor ambient relative humidity or indoor relative humidity (when enabled)
 - c. Enhance energy savings
 - 1) Cooling Mode:
 - a) Smart Load Control raises the system target low pressure during off-peak operation.
 - b) Raising the operating low pressure shall reduce the compressor lift, reduce compressor's speed and power consumption.
 - 2) Heating Mode
 - a) Smart Load control shall lower the system target high pressure during off-peak heating operation.
 - b) Lowering the operating high-pressure target shall reduce compressor lift, reduce compressor speed and power consumption.
 - c) Energy saved is in addition to the energy savings basic VRF load control provides.
 - d. Increased indoor comfort
 - 1) Smart Load control shall use one (or two) sensors to measure changing outdoor weather conditions and shall prepare the VRF system to operate under the revised weather conditions. This operation shall be activated before the changed ambient conditions have an impact on indoor units.
- 11. Field Supplied Refrigerant Piping Design Parameters
 - a. The outdoor unit shall be capable of operating at an elevation difference of up to of 164 feet above or 131 feet below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.
 - b. The outdoor unit shall be capable of operating with up to 984 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
 - c. The outdoor unit shall be capable of operating with up to 492 actual feet or 574 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
 - d. The elevation difference between the highest and lowest indoor units shall not exceed 49 feet.
 - e. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer's published guidelines.
 - f. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.
- 12. Defrost Operations
 - a. Heat Pump
 - 1) The outdoor unit(s) shall be capable of auto defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost

- cycle control shall monitor the outdoor ambient temperature and outdoor unit heat exchanger surface temperature.
- 2) The frequency of operating the defrost cycle shall be determined by the system's ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.
- b. Heat Recovery
- 1) The outdoor unit(s) shall be capable of intelligent defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature, humidity (if enabled), building load, and outdoor unit heat exchanger surface temperature in real time.
 - 2) The frequency of operating the defrost cycle shall be determined by the system's ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.
 - 3) The intelligent defrost algorithm shall be field selectable at the time of commissioning of the outdoor unit based on anticipated winter weather conditions. Intelligent defrost continuously calculates the dew point of the ambient air using the outdoor unit's temperature and humidity sensors (if enabled) and maintains the outdoor unit's coil surface temperature above the dew point delaying defrost operation while maintaining indoor space temperature.
 - 4) The intelligent defrost algorithm shall provide smart heating that will extend the system's heating operation and reduce the frequency of defrost cycles.
13. Oil Management
- a. The system shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts.
 - b. The system shall be provided with a factory installed oil separator at the discharge port of the compressor and designed to separate, condense, and collect oil vapor from the discharge refrigerant gas and return oil to the sump of the compressor. The oil separator shall have no moving parts in the separation chamber.
 - c. The system oil return control algorithm shall operate every 8 hours at a minimum, for a 3-minute period. When activated, the algorithm shall operate the system with the reversing valve in the cooling position, open all electronic expansion valves at the indoor unit(s) and raise the compressor speed to flush oil back to the compressor.

D. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.
2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

E. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
2. The compressor design shall be of the high-pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and minimize the mixing of refrigerant liquid with oil in the sump. The system shall employ a high pressure oil return method returning recovered oil from the oil separator directly into the oil sump of the compressor; oil shall not be allowed to return via the suction line. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero-bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 12Hz to 110 Hz.
3. The compressor(s) shall be wrapped with heat resistant foil faced, sound deadening blanket that covers all exposed surfaces of the compressor. Sound deadening blankets shall be secured in place by use of a Velcro™ tool-less joint sealing system with a minimum of ½" of overlap along all seams. The sound deadening compressor blanket shall be engineered to leave no direct sound path between the outer surface of the body of the compressor and the surrounding environment.
4. The compressor(s) shall be mounted on rubber isolation grommets. Compressor shall ship with removable clamps that secure the compressor in place while transported. The installing contractor shall remove and discard (or optionally adjust the clamps to allow the isolator to properly function) the clamps prior to commissioning the water source unit.
5. Manufacturers' published data shall include sound pressure and sound power levels.
 - a. Sound pressure level shall not exceed 57 dB(A) during cooling operation for Heat Pump and Heat Recovery outdoor units when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed
6. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. Low oil level.
 - c. High oil temperature.
 - d. Thermal and overload.
 - e. Voltage fluctuations.
 - f. Phase failure and phase reversal.
 - g. Short cycling.
7. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
8. Vibration Control: Integral isolation to dampen vibration transmission.
9. Oil management system to ensure safe and proper lubrication over entire operating range.
10. Crankcase heaters with integral control to maintain safe operating temperature.

11. Fusible plug.

F. Condenser Coil Assembly:

1. Plate Fin Coils:

- a. Casing: Aluminum, galvanized, or stainless steel.
- b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
- c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

- a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
- b. Single- or multiple-pass arrangement.
- c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Coating: Corrosion resistant.

4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

5. The outdoor unit coil shall have a minimum of 14 Fins per Inch (FPI).

6. The outdoor unit coil, all indoor units and the interconnecting field provided pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or specify field testing pressures at less than 550 psig shall not be acceptable.

G. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

- a. Direct-drive arrangement. direct drive variable speed axial flow fan(s) with a horizontal air discharge. Each fan shall be provided with an independent dedicated Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors
- b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
- c. Statically and dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.

3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.

4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.

6. Vibration Control: Integral isolation to dampen vibration transmission.

H. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
 - a. Refrigerant suction temperature.
 - b. Refrigerant discharge temperature.
 - c. Outdoor air temperature.
 - d. Refrigerant high pressure.
 - e. Refrigerant low pressure.
 - f. Oil level.
 - g. .
4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode , night setback control , power consumption display , run test switch equalize run time between multiple same components. Communication: Network communication with indoor units and other outdoor unit(s).
5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

K. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according to ASTM B117.

L. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.

2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 3. Field Piping Connections: Manufacturer's standard.
 4. Factory Charge: Dehydrated air or nitrogen.
 5. Testing: Factory pressure tested and verified to be without leaks.
- M. Wind Load Installations for Outdoor Units
1. Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010
- N. Seismic Installations
1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide LG supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.
- 2.10 HEAT RECOVERY UNITS (HRUs) (Branch Box)
- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
1. Specially designed for use in systems with simultaneous heating and cooling.
 2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
- B. Cabinet:
1. Galvanized-steel construction.
 2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
 3. Mounting: Manufacturer-designed provisions for field installation.
 4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- D. Refrigeration Assemblies and Specialties:
1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.
 2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.
 3. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.

4. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
5. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.
 - a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: .
4. Features and Functions: Self-diagnostics, fuse protection.
5. Communication: Network communication with indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.11 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRUs, and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.

2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
 - b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
 - c. Integration shall include control monitoring scheduling change of value notifications.
4. System Description
 - a. LG's Multi V™ Controls Network is the integrated controls platform for LG's Multi V™ Variable Refrigerant Flow (VRF) systems. The customizable Multi V™ Controls Network shall be programed for the level of control to as directed by the owner. Provide the controller options for space, central controller as specified and indicated in the schedules. Provide application controllers for third-party equipment control such as radiation valves, and BACnet™ interfaces for integration with Building Management Systems (BMS).
5. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Web interface through web browser software.
 - 2) The Premium Wired Remote Controller - PREMTA000. Refer to the specifications in this section.
 - b. Users shall be capable of interface with controllers for indoor units' control to extent privileges are enabled. Refer to the control features of the Remote Controller PREMTBVCO. Refer to the specifications in this section.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.

5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: English.
10. Supports Imperial and Metric Temperature Units: Fahrenheit or Celsius.
11. Displays service notifications and error codes.
12. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
13. Monitors and displays cumulative operating time of indoor units.
14. Able to disable and enable operation of individual controllers for indoor units.
15. Information displayed on individual controllers shall also be available for display.
16. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.

C. Central Controllers: (LG AC SMART 5 – PACS5A00)

1. Overview
 - a. The LG AC Smart 5 shall be capable of monitoring and control of up to 128 devices including indoor units, or 64 devices and 9 I/O Modules through its touchscreen interface and embedded web browser. The LG AC Smart 5 shall provide multiple energy management schemes and control of third-party equipment when paired with associated I/O Module. Additionally, the LG AC Smart 5 shall be capable of providing daily, weekly, yearly, and holiday programmable scheduling of Occupied/Unoccupied settings, On/Off, Mode of Operation, set point and fan speed based on the available functions of the connected system. Centralized control for all indoor and outdoor units from a single central controller location.
 - b. Include multiple interconnected controllers as required.
3. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
4. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - b. Sets schedule for daily, weekly, and annual events.
 - c. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.
5. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
6. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
7. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.

8. Service diagnostics tool.
 9. Able to disable and enable operation of individual controllers for indoor units.
 10. Information displayed on individual controllers shall also be available for display through central controller.
 11. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
 12. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
 13. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.
 14. Other General Features.
 - b. The LG AC Smart 5 shall communicate to the LG Multi V™ VRF indoor unit via the VRF RS-485 daisy-chain communication protocol.
 - c. The LG AC Smart 5 shall communicate to a third-party Building Automation System via BACnet/IP and Modbus TCP.
 - d. The LG AC Smart 5 shall have a 10.2" backlit touchscreen LCD display screen.
 - e. The LG AC Smart 5 shall have web access with user control.
 - f. The LG AC Smart 5 shall be able to generate an operation and error history log with reporting capabilities.
 - g. The LG AC Smart 5 shall be able to generate an operational trending report.
 - h. The LG AC Smart 5 shall be able to control up to 128 indoor units in a group or as a single zone.
 - i. The LG AC Smart 5 shall support two digital input and two digital outputs for device interlock.
 - j. The LG AC Smart 5 shall have two set point auto changeover.
 - k. The LG AC Smart 5 shall have occupied/unoccupied set point control.
 - l. The LG AC Smart 5 shall have remote controller lock (All, Setpoint, Mode, and Fan Speed).
 - m. The LG AC Smart 5 shall have error e-mail notification.
 - n. The LG AC Smart 5 shall have visual floor plan navigation.
- D. Wired Controllers for Indoor Units: CRC1 REMOTE CONTROLLER: PREMTBVC0
2. Overview:
 - b. The MultiSITE CRC1 Remote Controller shall be capable of controlling up to 16 indoor units (1 group). The MultiSITE CRC1 Remote Controller shall be capable of monitoring and controlling the group in terms of On/Off, Mode of Operation, Airflow direction, Fan Speed, space temperature, and space temperature Set Point. Additionally, the Remote Controller shall be capable of providing 7-day programmable scheduling of Occupied/Unoccupied settings, On/Off, Mode of operation, Set Point and Fan Speed. Remote Controllers shall be capable of communicating via the BACnet MS/TP protocol and the ability to communicate with wireless sensors.

3. Single controller capable of controlling multiple indoor units as group.
4. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
5. Multiple Language: English.
6. Temperature Units: Fahrenheit and Celsius.
7. On/Off: Turns indoor unit on or off.
8. Hold: Hold operation settings until hold is released.
9. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
10. Temperature Display: 1-degree increments.
11. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between.
12. Relative Humidity Display: 1 percent increments.
13. Relative Humidity Set-Point: Adjustable in 1 percent increments between.
14. Fan Speed Setting: Select between available options furnished with the unit.
15. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
16. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
17. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
18. Occupancy detection.
19. Service Notification Display: "Filter".
20. Service Run Tests: Limit use by service personnel to troubleshoot operation.
21. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
22. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
23. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
24. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.
25. Remote Controllers shall be capable of all of the following functions.
 - b. Communicate to the VRF indoor unit via the indoor unit remote controller communication bus.
 - c. Communicate with a BMS using BACnet MS/TP protocol.
 - d. Ability to communicate with wireless sensors using a ZigBee Pro Wireless Sensor network.
 - e. A touch-screen, backlit, LCD display with screen saver capability.
 - f. Support the ability to display or hide user accessible functions from the home screen.
 - g. Shall have an internal time clock and calendar.
 - h. Support the creation of five scheduled events per day.
 - i. Shall be able to create a scheduled event on a single page.
 - j. Shall be able to provide a summary view of currently applied schedules.
 - k. Shall be able to display temperature in °F or °C based on user settings and shall be able to be configured in either °F or °C for all functions.
 - l. Shall support and allow the scheduling of dual Set Point Auto operation in both occupied and unoccupied settings.
 - m. Shall have configuration menus based on roles: Building Manager, Installer, BMS Configuration and Basic Diagnostics.
 - n. Shall have a function code search capability.

- o. Shall be able to enable or dis-able Auxiliary Heat and Emergency Heat and be able to assign the primary heat source. (Aux heat kit required.)
- p. Shall be able to monitor and control up to 16 indoor units as a single group using the Group Control Wiring kit.
- q. Shall be able to initiate a Power Cooling Mode if supported by the available functions of the connected system. Retain "Wireless Controllers for Indoor Units" Paragraph below for indoor unit local controllers that are wireless.

Function	Description	Monitor	Control
On/Off	On/Off operation for group	X	X
Mode of Operation	Mode of Operation for group (Heat/Cool/Fan/Auto/Power Cool)	X	X
Set Point	Space temperature setpoint for group. Setting temperature range 64-84°F depending on operation mode and connected equipment.	X	X
Space Temperature	Display measured space temperature	X	
Fan Speed	Select fan speeds Low-Medium-High-Auto	X	X
Airflow Direction	Select air direction settings Auto/Swing/Fixed	X	X
Lock setting	Ability to lock out operation of the controller	X	X
Filter check	Notification to change dirty filter	X	
Temperature setpoint range limit	Ability to limit heating and cooling setpoint ranges	X	X
Schedule	7-day programmable schedule Maximum of 5 events per day with On/Off, Occ/UnOcc, Mode, Set temperature, and Fan Speed selectable per event.	X	X
Timed Override	Timed override of UnOcc settings	X	X
Occ/UnOcc Setting	Ability to have different settings for both modes	X	X
Operation Time Limit	Limit the run time of an indoor unit	X	X
Auto Changeover Deadband Adjust	Ability to adjust deadband between indoor unit heating and cooling modes	X	X
Set back	Ability to change heating and cooling setpoints	X	X
2 setpoint auto operation	Automatically manage room temperature for heating and cooling	X	
Central Control display	Display if a signal is received from Central Control	X	X

2.12 TWO-STAGE AUXILIARY HEAT CONTROL: PRARH1

C. Overview:

The LG Auxiliary Heater Two Relay Kit shall provide the capabilities to control two additional stages of heat for various applications by using function code setup in the Multi V system.

D. General:

1. The LG Two-Stage Auxiliary Heat Control shall be capable of enabling staging 2 additional stages of back up heat based on demand.
2. The LG Two-Stage Auxiliary Heat Control shall be capable of configuring the order of the heat source (Multi V / auxiliary heat source) so that either can be primary source of heat.

E. Electrical:

1. Power shall be 24 VAC

2.13 REFRIGERANT AND OIL

C. Refrigerant:

2. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
3. ASHRAE 34, Class A1 refrigerant classification.
4. R-410a.

D. Oil:

2. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.14 SYSTEM CONDENSATE DRAIN PIPING

C. If more than one material is listed, material selection is Contractor's option.

D. Copper Tubing:

2. Drawn-Temper Tubing: According to Type M or Type DWV according to ASTM B306.
3. Wrought-Copper Fittings: ASME B16.22.
4. Wrought-Copper Unions: ASME B16.22.
5. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

2.15 SYSTEM REFRIGERANT PIPING

C. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

D. Refrigerant Piping:

2. Copper Tube: ASTM B280, Type ACR.
3. Wrought-Copper Fittings: ASME B16.22.
4. Brazing Filler Metals: AWS A5.8/A5.8M.

E. Refrigerant Tubing Kits:

2. Furnished by VRF HVAC system manufacturer.

3. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
 4. Standard one-piece length for connecting to indoor units.
 5. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
 6. Factory Charge: Dehydrated air or nitrogen.
- F. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.
- G. Refrigerant Isolation Ball Valves:
2. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
 3. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
 4. Valve Connections: Flare or sweat depending on size.

2.16 METAL HANGERS AND SUPPORTS

- C. Copper Tube Hangers:
2. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized or copper-coated steel.

2.17 METAL FRAMING SYSTEMS

- C. MFMA Manufacturer Metal Framing Systems:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. G-Strut.
 - d. Unistrut; Atkore International.
 3. Description: Shop- or field-fabricated, pipe-support assembly for supporting multiple parallel pipes.
 4. Standard: MFMA-4.
 5. Channels: Continuous slotted steel channel with inturred lips.
 6. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
 8. Metallic Coating for Use Indoors: Electroplated zinc, hot-dip galvanized or mill galvanized.

9. Plastic Coating for Use Outdoors: PVC, polyurethane, epoxy or polyester.

2.18 FASTENER SYSTEMS

- C. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- D. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 2. Indoor Applications: Zinc-coated or stainless steel.
 3. Outdoor Applications: Stainless steel.

2.19 MISCELLANEOUS SUPPORT MATERIALS

- C. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 3. Design Mix: 5000-psi, 28-day compressive strength.
- D. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- E. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.20 PIPING AND TUBING INSULATION

- C. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.
- D. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:
 2. Flexible Elastomeric Insulation:
 - b. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - c. Indoors: 1/2 inch thick.
 - d. Outdoors: 1/2 inch thick.
 3. Field-Applied Jacket:
 - b. Concealed: None required.
 - c. Indoors, Exposed to View: PVC, color selected by engineer, 20 mils thick.
 - d. Outdoors, Exposed to View: None required.
- E. Refrigerant Tubing Insulation and Jacket Requirements:

2. Flexible Elastomeric Insulation:
 - b. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - c. Indoors: 1 inch thick.
 - d. Outdoors: 1 inch thick.
3. Field-Applied Jacket:
 - b. Concealed: None required.
 - c. Indoors outdoor, Exposed to View: PVC, 20 mils thick.

F. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

H. Metal Jacket Flashing Sealants:

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

2.21 SYSTEM CONTROL CABLE

C. Cable Rating: Listed and labeled for application according to NFPA 70.

2. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - b. Flame Travel Distance: 60 inches or less.
 - c. Peak Optical Smoke Density: 0.5 or less.
 - d. Average Optical Smoke Density: 0.15 or less.
3. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
4. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

D. Low-Voltage Control Cabling:

2. Paired Cable: NFPA 70, Type CMG.
 - b. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - c. PVC insulation.
 - d. Braided or foil shielded.

- e. PVC jacket.
 - f. Flame Resistance: Comply with UL 1685.
 - 3. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - b. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - c. PVC insulation.
 - d. Braided or foil shielded.
 - e. PVC jacket.
 - f. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - g. Flame Resistance: Comply with NFPA 262.
- E. TIA-485A Network Cabling:
 - 2. Standard Cable: NFPA 70, Type CMG.
 - b. Paired, [one pair] [two pairs], twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - c. PVC insulation.
 - d. Unshielded.
 - e. PVC jacket.
 - f. Flame Resistance: Comply with UL 1685.
 - 3. Plenum-Rated Cable: NFPA 70, Type CMP.
 - b. Paired, [one pair] [two pairs], No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - c. Fluorinated ethylene propylene insulation.
 - d. Unshielded.
 - e. Fluorinated ethylene propylene jacket.
 - f. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - g. Flame Resistance: NFPA 262.
- F. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.
 - 2. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
 - 3. Conductors: 100-ohm, 23 AWG solid copper.
 - 4. Shielding: Shielded twisted pairs (FTP).
 - 5. Cable Rating: By application.
 - 6. Jacket: White, Gray, Blue, or Yellow thermoplastic.
- G. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.22 MATERIALS

C. Steel:

2. ASTM A36/A36M for carbon structural steel.
3. ASTM A568/A568M for steel sheet.

D. Stainless Steel:

2. Manufacturer's standard grade for casing.
3. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

E. Galvanized Steel: ASTM A653/A653M.

F. Aluminum: ASTM B209.

G. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

H. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

2. Standards:

- b. ASTM B117 for salt spray.
- c. ASTM D2794 for minimum impact resistance of 100 in-lb.
- d. ASTM B3359 for cross-hatch adhesion of 5B.
3. Application: Immersion.
4. Thickness: 1 mil.
5. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.23 SOURCE QUALITY CONTROL

C. Factory Tests: Test and inspect factory-assembled equipment.

D. Equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports for historical record. Submit reports only if requested.

2.24 VIBRATION ISOLATION

- ### C.
- Floor mounted air handling units shall be mounted on free standing Spring isolators and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment and housekeeping pad. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated

deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be type SLR, as manufactured by Mason Industries, Inc

- D. All suspended air handling units shall use hanger consisting of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.11 EXAMINATION

- C. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- D. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- E. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- F. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- G. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- H. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- I. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- J. Proceed with installation only after unsatisfactory conditions have been corrected.

3.12 EQUIPMENT INSTALLATION, GENERAL

- C. Clearance:
2. Maintain manufacturer's recommended clearances for service and maintenance.
 3. Maintain clearances required by governing code.

- D. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

- 2. Loose components shall be installed by system Installer under supervision of manufacturer's service representative.

3.13 INSTALLATION OF INDOOR UNITS

- C. Install units to be level and plumb while providing a neat and finished appearance.
- D. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
- E. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
- F. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- G. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- H. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- I. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.
- J. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
- K. Install floor-mounted units on support structure indicated on Drawings.
- L. Attachment: Install hardware for proper attachment to supported equipment.
- M. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.14 INSTALLATION OF OUTDOOR UNITS

- C. Install units to be level and plumb while providing a neat and finished appearance.
- D. Install outdoor units on support structures indicated on Drawings.
- E. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Refer to plans and details for concrete pad detail
 - 2. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.15 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- C. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- D. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping and tubing to permit valve servicing.
- H. Install piping and tubing at indicated slopes.
- I. Install piping and tubing free of sags.
- J. Install fittings for changes in direction and branch connections.
- K. Install piping and tubing to allow application of insulation.
- L. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

3.16 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

- C. General Requirements for Drain Piping and Tubing:
 - 2. Install a union in piping at each threaded unit connection.
 - 3. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
 - 4. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - b. Details indicated on Drawings.
 - c. Manufacturer's requirements.
 - d. Governing codes.
 - e. In the absence of requirements, comply with requirements of ASHRAE handbooks.
 - 5. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.

6. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

D. Gravity Drains:

2. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

E. Pumped Drains:

2. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.17 INSTALLATION OF REFRIGERANT PIPING

C. Refrigerant Tubing Kits:

2. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
3. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 1/4 inch.
4. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

D. Install refrigerant piping according to ASHRAE 15 and governing codes.

E. Select system components with pressure rating equal to or greater than system operating pressure.

F. Install piping as short and direct as possible, with a minimum number of joints and fittings.

G. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

H. Install refrigerant piping and tubing in protective conduit where installed belowground.

I. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

J. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

2. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
3. Install horizontal suction lines with a uniform slope downward to compressor.

4. Install traps to entrain oil in vertical runs.
 5. Liquid lines may be installed level.
- K. When brazing, remove or protect components that could be damaged by heat.
- L. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- M. Joint Construction:
2. Ream ends of tubes and remove burrs.
 3. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 4. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - b. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - c. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.18 INSTALLATION OF METAL HANGERS AND SUPPORTS

- C. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- F. Fastener System Installation:
2. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 3. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
 4. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

- H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel.
 - 2. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- M. Piping and Tubing Insulation:
 - 2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 3. Shield Dimensions for Pipe: Not less than the following:
 - b. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
- N. Horizontal-Piping Hangers and Supports: Install the following types:
 - 2. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 4. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 5. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
 - 6. Pipe stands for horizontal pipes located outdoors.
 - 7. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 8. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- O. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
 - 2. Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 3. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 6. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 7. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.

8. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- P. Plastic Pipe Hanger and Support Spacing:
2. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
 3. Maximum spacing, 5 feet; minimum rod size, 1/4 inch.
- Q. Vertical-Piping Clamps: Install the following types:
2. Extension Pipe or Riser Clamps (MSS Type 8).
 3. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.
- R. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 10 feet.
- S. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- T. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- U. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- V. Trim excess length of continuous-thread hanger and support rods to 1 inch.
- W. Hanger-Rod Attachments: Install the following types:
2. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 3. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- X. Building Attachments: Install the following types:
2. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 3. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 4. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 5. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 6. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

7. C-Clamps (MSS Type 23): For structural shapes.
8. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
9. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
10. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
11. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
12. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
13. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - b. Light (MSS Type 31): 750 lb.
 - c. Medium (MSS Type 32): 1500 lb.
14. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
15. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
16. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.19 INSTALLATION OF PIPING AND TUBING INSULATION

- C. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.
- D. Insulation Installation on Pipe Fittings and Elbows:
 2. Install mitered sections of pipe insulation.
 3. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- E. Insulation Installation on Valves and Pipe Specialties:
 2. Install preformed valve covers manufactured of same material as pipe insulation when available.
 3. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- F. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints, for horizontal applications. Seal with manufacturer's recommended adhesive.

2. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

- G. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.20 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

- C. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
- D. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
- E. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."

3.21 ELECTRICAL INSTALLATION

- C. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- D. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.
 2. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
- E. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- F. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- G. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- H. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 2. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
 3. Locate nameplate or label where easily visible.
- I. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.

2. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
 3. Outlet boxes for cables shall be no smaller than 4 inches square by 1-1/2 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
 4. Flexible metal conduit shall not be used.
- J. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- K. Install manufactured conduit sweeps and long-radius elbows if possible.
- L. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.22 INSTALLATION OF SYSTEM CONTROL CABLE

- C. Comply with NECA 1.
- D. Installation Method:
2. Install cables in raceways except as follows:
 - b. Within equipment and associated control enclosures.
 - c. In accessible ceiling spaces where open cable installation method may be used.
 - d. In gypsum board partitions where cable may be enclosed within wall cavity.
 3. Conceal raceway and cables except in unfinished spaces.
- E. General Requirements for Cabling:
2. Comply with TIA-568-C Series of standards.
 3. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
 4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 5. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
 6. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
 7. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
 9. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.

10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
11. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
12. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
13. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
14. Provide strain relief.
15. Keep runs short. Allow extra length for connecting to terminals.
16. Do not bend cables in a radius less than 10 times the cable OD.
17. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
18. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

F. Balanced Twisted-Pair Cable Installation:

2. Comply with TIA-568-C.2.
3. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

G. Open-Cable Installation:

2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

H. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.23 FIRESTOPPING

- C. Comply with requirements in Section 078413 "Penetration Firestopping."
- D. Comply with TIA-569-D, Annex A, "Firestopping."
- E. Comply with BICSI TDMM, "Firestopping" Chapter.

3.24 GROUNDING INSTALLATION

- C. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- D. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.25 IDENTIFICATION

- C. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
 - D. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and equipment."
2. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.26 FIELD QUALITY CONTROL

- C. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
2. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.
- b. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.
3. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit. Provide four meeting as follows
- b. At approximately 25 percent completion of system(s).
 - c. At approximately 50 percent completion of system(s).
 - d. At approximately 75 percent completion of system(s).
 - e. Final inspection before system startup.
4. Site Visits: Activities for each site visit shall include the following:
- b. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - c. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
 - d. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - e. Advise and if necessary, assist Installer with updating related refrigerant calculations and system documentation.
 - f. Issue a report for each visit, documenting the visit.

- 1) Report to include name and contact information of individual making the visit.
- 2) Date(s) and time frames while on-site.
- 3) Names and contact information of people meeting with while on-site.
- 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

- b. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according to manufacturer's requirements and ready for final inspection.
- c. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
- d. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
- e. Inspection reports for indoor units shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.
 - 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.
 - 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.

- 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- f. Inspection reports for outdoor units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.
- g. Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Refrigerant piping properly connected and insulated.
 - 22) Condensate drain piping properly connected and insulated.
 - 23) Automatic dampers properly installed and operating.
 - 24) Ductwork properly connected.

- 25) If applicable, external interlocks properly connected.
- 26) Remarks.
- h. Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity readings.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Automatic dampers properly installed and operating.
 - 22) Ductwork properly connected.
 - 23) If applicable, external interlocks properly connected.
 - 24) Remarks.
- i. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
- j. Installer shall correct observed deficiencies found by the inspection.
- k. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
- l. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
- m. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.
- D. Perform the following tests and inspections with the assistance of manufacturer's service representative:
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Refrigerant Tubing Positive Pressure Testing:

2. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
3. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.
4. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
5. Prepare test report to record the following information for each test:
 - b. Name of person starting test, company name, phone number, and e-mail address.
 - c. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - d. Detailed description of extent of tubing tested.
 - e. Date and time at start of test.
 - f. Test pressure at start of test.
 - g. Outdoor temperature at start of test.
 - h. Name of person ending test, company name, phone number, and e-mail address.
 - i. Date and time at end of test.
 - j. Test pressure at end of test.
 - k. Outdoor temperature at end of test.
 - l. Remarks:
6. Submit test reports for Project record.

F. Refrigerant Tubing Evacuation Testing:

2. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
3. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
4. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
5. Prepare test report to record the following information for each test:
 - b. Name of person starting test, company name, phone number, and e-mail address.
 - c. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - d. Detailed description of extent of tubing tested.
 - e. Date and time at start of test.

- f. Test pressure at start of test.
 - g. Outdoor temperature at start of test.
 - h. Name of person ending test, company name, phone number, and e-mail address.
 - i. Date and time at end of test.
 - j. Test pressure at end of test.
 - k. Outdoor temperature at end of test.
 - l. Remarks:
 - 6. Submit test reports for Project record.
 - 7. Upon successful completion of evacuation testing, system shall be charged with refrigerant.
- G. System Refrigerant Charge:
- 2. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 - 3. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
 - 4. System refrigerant charging shall be witnessed by system manufacturer's representative.
 - 5. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- H. Products will be considered defective if they do not pass tests and inspections.
- I. Prepare test and inspection reports.
- 3.27 STARTUP SERVICE
- C. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
- 2. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
 - 3. Complete startup service of each separate system.
 - 4. Complete system startup service according to manufacturer's written instructions.
- D. Startup checks shall include, but not be limited to, the following:
- 2. Check control communications of equipment and each operating component in system(s).
 - 3. Check each indoor unit's response to demand for cooling and heating.
 - 4. Check each indoor unit's response to changes in airflow settings.
 - 5. Check each indoor unit, HRU, and outdoor unit for proper condensate removal.
 - 6. Check sound levels of each indoor and outdoor unit.

- E. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.
 - 2. Installer shall correct deficiencies found during startup service for reverification.
- F. System Operation Report:
 - 2. After completion of startup service, manufacturer shall issue a report for each separate system.
 - 3. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
 - 4. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - b. All available system operating parameters shall be included in the information submitted.
- G. Witness:
 - 2. Invite engineer Owner to witness startup service procedures.
 - 3. Provide written notice not less than 20 business days before start of startup service.

3.28 ADJUSTING

- C. Adjust equipment and components to function smoothly and lubricate as recommended by manufacturer.
- D. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- E. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.
- F. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.29 PROTECTION

- C. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- D. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

- E. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- F. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.30 MAINTENANCE SERVICE

- C. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system who are trained Installer manufacturer's authorized service representative. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.31 SOFTWARE SERVICE AGREEMENT

- C. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- D. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

3.32 DEMONSTRATION

- C. Engage a VRF HVAC system manufacturer's employed training instructor or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- D. Instructor:
 - 2. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
 - 3. Instructor's credentials shall be submitted for review by engineer or Owner before scheduling training.
 - 4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience. Schedule and Duration:
 - 5. Schedule training with Owner at least 20 business days before first training session.
 - 6. Training shall occur before Owner occupancy.
 - 7. Provide two separate 4 hr. training sessions
 - 8. Perform not less than eight total hours of training.
- E. Location: Owner shall provide a suitable on-site location to host classroom training.

- F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
- H. Training Materials: Provide training materials in electronic format to each attendee.
 - 2. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 3. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain engineer written acceptance that training is complete, and requirements indicated have been satisfied.

END OF SECTION 238129

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

- A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Alpha Wire Company.
 - 2. Belden Inc.
 - 3. Cerro Wire LLC.
 - 4. Encore Wire Corporation.
 - 5. General Cable Technologies Corporation.
 - 6. General Cable; General Cable Corporation.
 - 7. Senator Wire & Cable Company.
 - 8. Southwire Company.
- B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2, Type XHHW-2 and Type SO.

- D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC mineral-insulated, metal-sheathed cable, Type MI and Type SO with ground wire.
- E. VFC Cable:
 - 1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
 - 2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. 3M.
 - 2. AFC Cable Systems, Inc.
 - 3. Gardner Bender.
 - 4. Hubbell Power Systems, Inc.
 - 5. Ideal Industries, Inc.
 - 6. ILSCO.
 - 7. NSi Industries LLC.
 - 8. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 - 9. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

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

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway or Mineral-insulated, metal-sheathed cable, Type MI.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway, Metal-clad cable, Type MC or Mineral-insulated, metal-sheathed cable, Type MI.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. VFC Output Circuits: Type TC-ER cable with braided shield.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

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

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

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

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

- b. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- B. Test and Inspection Reports: Prepare a written report to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Burndy; Part of Hubbell Electrical Systems.

2. ERICO International Corporation.
3. Galvan Industries, Inc.; Electrical Products Division, LLC.
4. Harger Lightning & Grounding.
5. ILSCO.
6. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
7. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

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

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating

sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- E. Metallic Fences: Comply with requirements of IEEE C2.
 - 1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
 - 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
 - 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 2. For grounding electrode system, install at least two rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- D. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- G. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Manhole Grounds: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Hangers.
 - b. Steel slotted support systems.
 - c. Trapeze hangers.
 - d. Clamps.
 - e. Turnbuckles.
 - f. Sockets.
 - g. Eye nuts.
 - h. Saddles.
 - i. Brackets.
 - 2. Include rated capacities and furnished specialties and accessories.
- B. Delegated-Design Submittal: For hangers and supports for electrical systems.
 - 1. Include design calculations and details of trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M.
 - 2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation, A Member of the ABB Group.
 - f. Unistrut; an Atkore International company.
 - 2. Material: Galvanized steel.
 - 3. Channel Width: 1-5/8 inches.
 - 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

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

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.
- B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

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

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetal conduits, tubing, and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Surface raceways
 - 5. Boxes, enclosures, and cabinets.
 - 6. Handholes and boxes for exterior underground cabling.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit.

3. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 4. Republic Conduit.
 5. Southwire Company.
 6. Thomas & Betts Corporation, A Member of the ABB Group.
 7. Western Tube and Conduit Corporation.
 8. Wheatland Tube Company.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. IMC: Comply with ANSI C80.6 and UL 1242.
- E. EMT: Comply with ANSI C80.3 and UL 797.
- F. FMC: Comply with UL 1; zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: Compression.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- I. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
- 2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS
- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. AFC Cable Systems, Inc.
 2. Arnco Corporation.
 3. CANTEX INC.
 4. CertainTeed Corporation.
 5. Kraloy.

6. RACO; Hubbell.
7. Thomas & Betts Corporation, A Member of the ABB Group.

- B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Cooper B-Line, Inc.; a division of Cooper Industries.
 2. Hoffman; a brand of Pentair Equipment Protection.
 3. MonoSystems, Inc.
 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. MonoSystems, Inc.
 - c. Legrand/Wiremold
 - d. Panduit

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Cooper Technologies Company.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman; a brand of Pentair Equipment Protection.
 5. Hubbell Incorporated.
 6. MonoSystems, Inc.
 7. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 8. RACO; Hubbell.
 9. Thomas & Betts Corporation, A Member of the ABB Group.
 10. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
 1. Material: Cast metal or sheet metal.
 2. Type: Fully adjustable.
 3. Shape: Rectangular.
 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- K. Gangable boxes are allowed.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- M. Cabinets:
 - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. NewBasis.
 - d. Oldcastle Precast, Inc.
 - e. Quazite: Hubbell Power Systems, Inc.

- f. Synertech Moulded Products.
 - 2. Standard: Comply with SCTE 77.
 - 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 6. Cover Legend: Molded lettering, "ELECTRIC."
 - 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 - 8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by an independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: GRC or IMC.
 - 2. Concealed Conduit, Aboveground: GRC or IMC.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC or Type EPC-80-PVC.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 - 3. Exposed and Subject to Severe Physical Damage: GRC or IMC. Raceway locations include the following:
 - a. Loading dock.
 - b. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: GRC or IMC.
 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use compression, steel or cast-metal fittings. Comply with NEMA FB 2.10.
 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

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

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 5. Change from RNC, Type EPC-40-PVC to GRC or IMC before rising above floor.
- J. Stub-ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- M. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- O. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- P. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- Q. Surface Raceways:
1. Install surface raceway with a minimum 2-inch radius control at bend points.
 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

- R. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- S. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- T. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- U. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- V. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC in damp or wet locations not subject to severe physical damage.
- W. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to bottom of box unless otherwise indicated.
- X. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- Y. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- Z. Locate boxes so that cover or plate will not span different building finishes.
- AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- CC. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

- B. Related Requirements:

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:

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

- B. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

- a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
- b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 3. Pressure Plates: Plastic.
 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. HOLDRITE.

2.4 GROUT

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

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall, so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

- B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

- C. Warning labels and signs shall include, but are not limited to, the following legends:

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

2.3 LABELS

- A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Champion America.
 - c. emedco.
 - d. Grafoplast Wire Markers.
 - e. LEM Products Inc.
 - f. Marking Services, Inc.
 - g. Panduit Corp.
 - h. Seton Identification Products.

- B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Panduit Corp.
 - d. Seton Identification Products.

C. Self-Adhesive Labels:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. emedco.
 - e. Grafoplast Wire Markers.
 - f. Ideal Industries, Inc.
 - g. LEM Products Inc.
 - h. Marking Services, Inc.
 - i. Panduit Corp.
 - j. Seton Identification Products.
2. Preprinted, 3-mil-thick, polyester or vinyl flexible label with acrylic pressure-sensitive adhesive.
 - a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable or raceway diameter, such that the clear shield overlaps the entire printed legend.
3. Polyester or Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
 - a. Nominal Size: 3.5-by-5-inch.
4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

- A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. Brady Corporation.
- b. Marking Services, Inc.
- c. Panduit Corp.

- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. Brady Corporation.
- b. Panduit Corp.

2.5 TAPES AND STENCILS:

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. Carlton Industries, LP.
- b. Champion America.
- c. Ideal Industries, Inc.
- d. Marking Services, Inc.
- e. Panduit Corp.

- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. Brady Corporation.
- b. Carlton Industries, LP.
- c. emedco.
- d. Marking Services, Inc.

- C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. LEM Products Inc.
 - b. Marking Services, Inc.
 - c. Seton Identification Products.
- D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Carlton Industries, LP.
 - b. Seton Identification Products.
- E. Underground-Line Warning Tape
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Ideal Industries, Inc.
 - c. LEM Products Inc.
 - d. Marking Services, Inc.
 - e. Reef Industries, Inc.
 - f. Seton Identification Products.
 2. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 3. Color and Printing:
 - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
 4. Tag:

- a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Overall Thickness: 5 mils.
 - d. Foil Core Thickness: 0.35 mil.
 - e. Weight: 28 lb/1000 sq. ft..
 - f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.
- F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 Tags

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.
 - e. Seton Identification Products.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Grafoplast Wire Markers.
 - e. LEM Products Inc.
 - f. Marking Services, Inc.
 - g. Panduit Corp.
 - h. Seton Identification Products.
- C. Write-On Tags:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Carlton Industries, LP.
 - b. LEM Products Inc.
 - c. Seton Identification Products.
2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.
4. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. emedco.
 - d. Marking Services, Inc.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.
4. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Champion America.
 - c. emedco.
 - d. Marking Services, Inc.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.

2. Thickness:

- a. For signs up to 20 sq. inches, minimum 1/16-inch-
- b. For signs larger than 20 sq. inches, 1/8 inch thick.
- c. Engraved legend with black letters on white face.
- d. Punched or drilled for mechanical fasteners.
- e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

3. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. Brady Corporation.
- b. Carlton Industries, LP.
- c. emedco.
- d. Marking Services, Inc.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.

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

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

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

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

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.

5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated.
- I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

- J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

- A. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Snap-around labels. Install labels at 10-foot maximum intervals.
- B. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.
- C. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "STANDBY POWER."
 - 2. "POWER."
 - 3. "UPS."
- D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.

3) Phase C: Yellow.

- d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- E. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
- F. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.
- G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.
- H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive, self-laminating polyester labels with the conductor designation.
- I. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.
- J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- K. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
 - 1. Limit use of underground-line warning tape to direct-buried cables.
 - 2. Install underground-line warning tape for direct-buried cables and cables in raceways.
- L. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Metal-backed, butyrate warning signs.

1. Comply with 29 CFR 1910.145.
 2. Identify system voltage with black letters on an orange background.
 3. Apply to exterior of door, cover, or other access.
 4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- N. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- O. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.
- P. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
 2. Equipment To Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchboards.
 - e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - f. Emergency system boxes and enclosures.

- g. Enclosed switches.
- h. Enclosed circuit breakers.
- i. Enclosed controllers.
- j. Variable-speed controllers.
- k. Push-button stations.
- l. Power-transfer equipment.
- m. Contactors.
- n. Remote-controlled switches, dimmer modules, and control devices.
- o. Battery-inverter units.
- p. Power-generating units.
- q. Monitoring and control equipment.
- r. UPS equipment.

END OF SECTION 260553

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Time switches.
 - 2. Photoelectric switches.
 - 3. Standalone daylight-harvesting switching and dimming controls.
 - 4. Indoor occupancy and vacancy sensors.
 - 5. Switchbox-mounted occupancy sensors.
 - 6. Digital timer light switches.
 - 7. High-bay occupancy sensors.
 - 8. Extreme temperature occupancy sensors.
 - 9. Outdoor motion sensors.
 - 10. Lighting contactors.
 - 11. Emergency shunt relays.

- B. Related Requirements:

- 1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings:

- 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On USB media. Provide names, versions, and website addresses for locations of installed software.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
 - 2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY AND VACANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Acuity Brands.
 - 2. Cooper Industries, Inc.
 - 3. Leviton Manufacturing Co., Inc.
- B. General Requirements for Sensors:
 - 1. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
 - 2. Dual technology.
 - 3. Integrated power pack.
 - 4. Hardwired connection to switch; and BAS and lighting control system.
 - 5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 6. Operation:
 - a. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A Sensor is powered from the power pack Wireless.
 8. Power: Line voltage.
 9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 10. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 12. Bypass Switch: Override the "on" function in case of sensor failure.
 13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet when mounted 48 inches above finished floor.

2.2 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Acuity Brands.
 2. Cooper Industries, Inc.
 3. Leviton Manufacturing Co., Inc.
- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, manual "on," automatic "off" or SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: as specified by architect.
11. Faceplate: Color matched to switch.

2.3 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ASCO Power Technologies, LP; a business of Emerson Network Power.
2. Eaton.
3. General Electric Company.
4. Square D.

B. Description: Electrically operated and electrically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.4 EMERGENCY SHUNT RELAY

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Lighting Control and Design.
 - 2. WattStopper; a Legrand® Group brand.
- B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
 - 1. Coil Rating: as specified on drawings.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 CONTACTOR INSTALLATION

- A. Comply with NECA 1.
- B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.
- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Lighting control devices will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
- B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 260943.16 - ADDRESSABLE-LUMINAIRE LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes lighting controls for addressable luminaires, based on DALI digital controls.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. DALI: Digital addressable lighting interface.
- C. Data Bus: Two wires used to communicate with bus connected devices.
- D. DDC: Direct digital control.
- E. Device: A collective term for DALI-compliant bus connected devices, including fluorescent ballasts, incandescent luminaires, manual switches, switching relays, and similar. Sometimes also called "slave unit."
- F. Group: A set of devices that respond at the same time to messages on the data bus.
- G. IP: Internet protocol.
- H. IR: Infrared.
- I. LAN: Local area network.
- J. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- K. Scene: Digital light level associated with a preset; stored in the luminaire ballast.
- L. TCP/IP: Transmission control protocol/Internet protocol.
- M. VPN: Virtual private network.

1.4 ACTION SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Sound data including results of operational tests of central dimming controls.
4. Operational documentation for software and firmware.

B. Shop Drawings:

1. Floor Plans: Location, orientation, and coverage area of each sensor; group designations; and other specific design symbols and designations as required to define the installation, location, and configuration of all control devices.
2. Address Drawing: Reflected ceiling plan and floor plans, showing data-bus-connected devices, address for each device, and device groups. The plans shall be based on construction plans, using the same legend, symbols, and schedules.
3. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads connected to each data bus and total connected load for each data bus. Include percentage of rated connected load and device addresses.
4. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.
- C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On USB drive.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.

6. Operation of adjustable zone controls.
7. Testing and adjusting of panic and emergency power features.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Bus Power Supplies: Equal to two percent of amount installed, but no fewer than two.
 2. Controller/Gateways: Equal to two percent of amount installed, but no fewer than two.
 3. Incandescent Switching and Dimming Modules: Equal to two percent of amount installed, but no fewer than two.
 4. Fluorescent Ballasts: Equal to two percent of amount installed, but no fewer than two.
 5. Lighting Control Relays: Equal to two percent of amount installed, but no fewer than two.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Software: Failure of input and output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.
 - c. Ballast failure.
 - d. Damage of electronic components due to transient voltage surges.
 2. Warranty Periods:
 - a. For DALI Ballasts: Three years from date of Substantial Completion.
 - b. For Control Components That Are Not Part of Ballasts: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. DALI:
 1. Components: Individually addressable devices (such as ballasts, relays, dimmers, and switches) that are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as computers, Internet portals, hand-held IR programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs. Devices also report status to data-entry and -retrieval devices through the bus.

2. Digital Control: Use peer-to-peer communication and distributed logic, where the failure of any single component shall be automatically isolated and not affect global system functions.

B. Ethernet LAN:

1. Provide an Ethernet LAN to connect controller/gateways to a PC running a Microsoft Windows operating system. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."
2. Ethernet Protocols: Comply with and be compatible with 10/100 BaseT TCP/IP routers and networks.
3. TCP/IP Modem: Capable of maintaining a secure Internet connection using VPN or equivalent protocol.

2.2 BUS POWER SUPPLY

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Acuity Brands.
2. Leviton Manufacturing Co., Inc.
3. Lightolier; a Philips group brand.

- B. Description: Supply power to data bus for 64 addressable devices, suitable for use with NFPA 70, Class 2 control circuit.

1. Primary Power: Field selectable, 120 and 277 V.
2. Power Supply: Regulated to maintain the operating voltage above 15-V dc under full load, and rated for full charging load of 250 mA and a minimum maintained connected load of 190 mA.
3. Pilot Lights: Indicate data bus ground-fault and data bus traffic.

2.3 CONTROLLER/GATEWAYS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Acuity Brands.
2. Leviton Manufacturing Co., Inc.
3. Lightolier; a Philips group brand.

- B. Description: DALI controller/gateways link the distributed data buses with an Ethernet network to provide computer configuration, control, analysis, and maintenance. Controller/gateways operate independently and continue to process local inputs and schedules when disconnected from the LAN. Controller/gateways shall provide local intelligence and features including the following:

1. Integrated real-time clock with automatic daylight savings adjustment and leap-year correction.
 2. Integrated sunrise/sunset support based on the site location (latitude and longitude).
 3. Automatic time schedules, to control groups for scheduled occupancy with support for holiday exceptions.
 4. Two digital outputs for additional control and interlocking with external equipment such as fans, valves, and security panels.
 5. Support two data bus(es).
 6. Computer Monitoring and Configuration: The controller/gateway shall allow configuration, monitoring, and analysis from PCs on the Ethernet LAN.
- C. Each data bus shall have the capacity to control 64 addressable devices, using NFPA 70, Class 2 control circuit.
1. Each data bus shall have the capacity to control up to 16 groups and scenes.
 2. 10 BaseT Ethernet port for DDC system for HVAC connection.
 3. LED indicator lights for Ethernet status (link, send, and receive), power-on, and LAN failure.
 4. Linking of switch and sensor inputs to relay and ballast outputs.
 5. Viewing relay and ballast output status.
 6. Controlling relay and ballast outputs.
 7. Setting device addresses.
 8. Assigning switch and sensor inputs and relay and ballast output modes.
- D. Allow connection of the following DALI-compliant addressable devices:
1. LED luminaire switching and dimming.
 2. Occupancy and photoelectric sensors.
 3. Emergency lighting interface complying with UL 924.
- E. Stores system programming in nonvolatile memory.
1. Switch to enable or disable software programming.

2.4 LIGHTING CONTROL SYSTEM MANAGEMENT SOFTWARE

- A. The software shall provide for programming, configuring, and monitoring all devices connected to all data buses of the lighting control system, using application-specific software with Microsoft Windows-based, user-friendly software with graphical user-interface designed screens.
1. The software shall be object oriented with pop-up menus and built-in help screens. All specified features of the data-bus-connected devices and those associated with controller/gateways shall be included in the software.

2.5 LUMINAIRE SWITCHING AND DIMMING MODULES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Acuity Brands.
2. Leviton Manufacturing Co., Inc.
3. Lightolier; a Philips group brand.

- B. Description: Comply with DALI exponential dimming curve calibrated for the connected lamp type, group, and scene settings, and with DALI light-level and configuration commands. Dimmer rise time shall be not less than 15 microseconds.

2.6 BALLAST SWITCHING AND DIMMING MODULES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Acuity Brands.
2. Lutron Electronics Co., Inc.
3. OSRAM SYLVANIA.

- B. Each ballast or group shall be addressable and shall include on-off, fade, dimming, scene settings, and other standard DALI control functions and as required to meet the sequence of operation.

2.7 SENSORS

- A. Comply with requirements in Section 260923 "Lighting Control Devices." All sensors shall be DALI-protocol compliant.

- B. Daylight Harvesting Switching and Dimming Controls:

1. Adjustments and Set Points: All adjustments with exception of sensor range shall be made via the communication network.
2. Remote Monitoring and Reporting: Sensor value shall be displayed when queried by lighting management software or shall automatically report based on a change of value or change of time period setting.

- C. Indoor Occupancy Sensors: May be powered directly from the lighting control network or with a standalone power supply. Units powered with a standalone power supply shall interface with the lighting control system through an electrically isolated digital input.

2.8 RELAYS

- A. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating shall be not less than 5 kA. Pilot light indicates when relay is closed and latched. Control shall be by DALI digital data bus. Relay status shall be displayed when queried by lighting management software.

- B. Relay Panel: A single enclosure with incoming lighting branch circuits, relays, and connection to the DALI digital control network.

1. Enclosure: NEMA 250, Type 1 unless otherwise indicated.
2. Barriers to separate low-voltage and line-voltage components.
3. Directory: Cover mounted, identifying each relay with its device address and naming the load controlled.

C. Individually Mounted Relays:

1. Enclosure: Standard outlet box or NEMA 250, Type 1 unless otherwise indicated.
2. Directory: Cover mounted, identifying each relay with its device address.

2.9 MANUAL SWITCHES AND PLATES

- A. Connection Type: RS-485 protocol, Category 5e UTP cable, using RJ-45 connectors. Power shall be from the control unit.
- B. Push-Button Switches: Modular, operating over the DALI digital data bus.
1. Each switch shall control the following functions, in coordination with programmed sequence of operation and related sensors:
 - a. On.
 - b. Off.
 - c. Dimming, increase light level.
 - d. Dimming, decrease light level.
 - e. Return to preset light level.
 2. LED Pilot Lights: On to indicate that the control is active, or when the manual control is operated.
 3. Match color and style specified in Section 262726 "Wiring Devices."
 4. Integral IR receiver for programming.
- C. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."
- D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.10 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- D. Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with Category 5e for horizontal copper cable and with Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

- A. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Identify all ceiling-mounted controls with data bus number and device address.
- D. Label each device cable within 6 inches of connection to bus power supply or termination block.

3.3 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test each bus controller using local and remote controls.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Field Test Reports:
 - 1. Printed list of all points created from actual queries of all addressed control points to include lamps, ballasts, manual controls, and sensors.

2. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.

D. Lighting controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Activate luminaires and verify that all lamps are operating at 100 percent.
3. Burn-in fluorescent lamps at 100 percent for 100 hours.
4. Confirm correct communications wiring, initiate communications between DALI devices and controller/gateways, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 260943.16

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 4. Detail bus configuration, current, and voltage ratings.
 - 5. Short-circuit current rating of panelboards and overcurrent protective devices.

6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

- a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
- b. Altitude: Not exceeding 6600 feet.

- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

- A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 1.
- D. Comply with NFPA 70.
- E. Enclosures: Flush and Surface-mounted, dead-front cabinets.
 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 4.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 2. Height: 84 inches maximum.

3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
 4. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
- F. Incoming Mains:
1. Location: Convertible between top and bottom.
 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- G. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- H. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Terminations shall allow use of 75 deg C rated conductors without derating.
 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
 6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: 20 percent.
- J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company; GE Energy Management - Electrical Distribution.
 3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company; GE Energy Management - Electrical Distribution.
 3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only.

- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Sector; Eaton Corporation.
 - 2. General Electric Company; GE Energy Management - Electrical Distribution.
 - 3. Siemens Energy.
 - 4. Square D; by Schneider Electric.
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 - 3. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 4. Subfeed Circuit Breakers: Vertically mounted.
 - 5. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
 - i. Multipole units enclosed in a single housing with a single handle.

- j. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
- C. Circuit breakers installed in existing panelboards shall be UL listed for use in the panelboards in which they are installed.

2.5 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NEMA PB 1.1.
- D. Equipment Mounting:
 - 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.
- J. Mount surface-mounted panelboards to steel slotted supports 1 1/4 inch in depth. Orient steel slotted supports vertically.
- K. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- M. Install filler plates in unused spaces.
- N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Perform optional tests. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 - 1. Measure loads during period of normal facility operations.
 - 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 - 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. USB charger devices.
 - 3. Twist-locking receptacles.
 - 4. Weather-resistant receptacles.
 - 5. Snap switches.
 - 6. Pendant cord-connector devices.
 - 7. Cord and plug sets.
 - 8. Floor service outlets and poke-through assemblies.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- C. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.6 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

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

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
 - 2. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - 2. Hubbell Incorporated; Wiring Device-Kellems.
 - 3. Leviton Manufacturing Co., Inc.
 - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

2.3 USB CHARGER DEVICES

- A. Tamper-Resistant, USB Charger Receptacles: 12 V dc, 2.0 A, USB Type A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.

- c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
- 2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
- 3. USB Receptacles: Dual, Type A.
- 4. Line Voltage Receptacles: Dual, two pole, three wire, and self-grounding.

2.4 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration as indicated on drawings, and UL 498.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

2.5 PENDANT CORD-CONNECTOR DEVICES

- A. Description:
 - 1. Matching, locking-type plug and receptacle body connector.
 - 2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
 - 3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
 - 4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

- A. Description:
 - 1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - 2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
 - 3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 DECORATOR-STYLE DEVICES

- A. Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
- B. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943 Class A.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
- C. GFCI, Weather-Resistant Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943 Class A.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Pass & Seymour/Legrand (Pass & Seymour).
- D. Toggle Switches, Square Face, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

- E. Lighted Toggle Switches, Square Face, 120 V, 20 A: Comply with NEMA WD 1 and UL 20.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 - 2. Description: With neon-lighted handle, illuminated when switch is "off."
- F. All branch circuits rated at 15 amperes shall only have receptacles rated at 15 amperes connected to it.

2.8 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
 - 3. Material for Unfinished Spaces: Galvanized steel.
 - 4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.9 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, solid brass with satin finish.
- D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

2.10 POKE-THROUGH ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Pass & Seymour/Legrand (Pass & Seymour).
 - 3. Square D; by Schneider Electric.

4. Thomas & Betts Corporation, A Member of the ABB Group.
5. Wiremold / Legrand.

B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Pedestal type with services indicated.
4. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables.

2.11 FINISHES

A. Device Color:

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

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

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

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

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

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

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- B. Tests for Convenience Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Switchboards.
 - c. Enclosed controllers.
 - d. Enclosed switches.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles. Include the following for each fuse type indicated:
 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 2. Coordination charts and tables and related data.
 3. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," include the following:
 1. Ambient temperature adjustment information.
 2. Current-limitation curves for fuses with current-limiting characteristics.
 3. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussmann; a division of Cooper Industries.
 - 2. Edison; a brand of Cooper Bussmann; a division of Cooper Industries.
 - 3. Littelfuse, Inc.
 - 4. Mersen USA.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 - 1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 - 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
 - 3. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
 - 4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Service Entrance: Class L, time delay.
 - 2. Feeders: Class RK1, time delay.
 - 3. Motor Branch Circuits: Class RK1, time delay.
 - 4. Power Electronics Circuits: Class J, high speed.
 - 5. Other Branch Circuits: Class J, fast acting.
 - 6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
 - 7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Fusible switches.
- 2. Nonfusible switches.
- 3. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 2. Fuse Pullers: Two for each size and type.

1.8 QUALITY ASSURANCE

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

1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 2. Altitude: Not exceeding 6600 feet.

1.10 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Sector; Eaton Corporation.
 - 2. General Electric Company.
 - 3. Siemens Industry, Inc.
 - 4. Square D; by Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 - 5. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 6. Service-Rated Switches: Labeled for use as service equipment.
 - 7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Sector; Eaton Corporation.
 - 2. General Electric Company.
 - 3. Siemens Industry, Inc.
 - 4. Square D; by Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.
5. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 4.
 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

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

END OF SECTION 262816

SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCE SUPPRESSOR

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ABB USA.
 - 2. Advanced Protection Technologies Inc. (APT).
 - 3. Alltec Corporation.
 - 4. Current Technology Inc.
 - 5. Eaton Electrical Sector; Eaton Corporation.
 - 6. General Electric Company.
 - 7. LEA International.
 - 8. Leviton Manufacturing Co., Inc.
 - 9. Liebert; a brand of Emerson Electric Co.
 - 10. Schneider Electric USA, Inc.
 - 11. Siemens Industry, Inc.
 - 12. Square D; by Schneider Electric.
- B. SPDs: Comply with UL 1449, Type 2.
 - 1. SPDs with the following features and accessories:
 - a. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

- b. Indicator light display for protection status.
 - c. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - d. Surge counter.
 - C. Comply with UL 1283.
 - D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
 - E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 1200 V for 480Y/277 V.
 - 2. Line to Ground: 1200 V for 480Y/277 V.
 - 3. Line to Line: 2000 V for 480Y/277 V.
 - 4. Line to Neutral: 700 V for 208Y/120 V.
 - 5. Line to Ground: 1200 V for 208Y/120 V.
 - 6. Line to Line: 1000 V for 208Y/120 V.
 - F. SCCR: Equal or exceed 100 kA.
 - G. Inominal Rating: 20 kA.
- 2.3 PANEL SUPPRESSORS
- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ABB USA.
 - 2. Advanced Protection Technologies Inc. (APT).
 - 3. Alltec Corporation.
 - 4. Atlantic Scientific.
 - 5. Current Technology Inc.
 - 6. Eaton Electrical Sector; Eaton Corporation.
 - 7. General Electric Company.
 - 8. LEA International.
 - 9. Leviton Manufacturing Co., Inc.
 - 10. Liebert; a brand of Emerson Electric Co.
 - 11. Northern Technologies, Inc.
 - B. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 700 V for 208Y/120 V.
 2. Line to Ground: 700 V for 208Y/120 V.
 3. Neutral to Ground: 700 V for 208Y/120 V.
 4. Line to Line: 1200 V for 208Y/120 V
- E. SCCR: Equal or exceed 100 kA.
- F. Inominal Rating: 20 kA.

2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

- C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.
- E. Wiring:
 - 1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized and tested.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Interior solid-state luminaires that use LED technology.
 - 2. Lighting fixture supports.

- B. Related Requirements:

- 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of luminaires.
 - 4. Include emergency lighting units, including batteries and chargers.
 - 5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
 - 6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each

lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project.

- a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

- A. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of luminaire.
- C. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Provide luminaires from a single manufacturer for each luminaire type.

- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. Recessed Fixtures: Comply with NEMA LE 4.
- D. Bulb shape complying with ANSI C79.1.
- E. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- F. Rated lamp life of 35,000 hours.
- G. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- H. Internal driver.
- I. Nominal Operating Voltage: As indicated on Plans.
 - 1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- J. Housings:
 - 1. Extruded-aluminum housing and heat sink.
 - 2. powder-coat finish.

2.2 DOWNLIGHT

- A. See Plans for manufacturers.

- B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Universal mounting bracket.
- D. Integral junction box with conduit fittings.

2.3 LINEAR INDUSTRIAL

- A. See Plans for manufacturers.
- B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Housing and heat sink rated to the following:
 - 1. NEMA 4X.
 - 2. IP 54.
 - 3. IP 66.
 - 4. Marine and wet locations.
 - 5. CSA C22.2 No 137.

2.4 RECESSED LINEAR

- A. See Plans for manufacturers.
- B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.
- C. Integral junction box with conduit fittings.

2.5 STRIP LIGHT

- A. See Plans for manufacturers.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.6 SURFACE MOUNT, LINEAR

- A. See Plans for manufacturers.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.7 SURFACE MOUNT, NONLINEAR

- A. See Plans for manufacturers.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.8 SUSPENDED, LINEAR

- A. See Plans for manufacturers.
- B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.9 SUSPENDED, NONLINEAR

- A. See Plans for manufacturers.
- B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.
- C. Integral junction box with conduit fittings.

2.10 MATERIALS

- A. Metal Parts:
 - 1. Free of burrs and sharp corners and edges.
 - 2. Sheet metal components shall be steel unless otherwise indicated.
 - 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Diffusers and Globes:
 - 1. prismatic acrylic
 - 2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- D. Housings:
 - 1. Extruded-aluminum housing and heat sink.
 - 2. powder-coat finish.
- E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI for all luminaires.

2.11 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.12 LUMINAIRE FIXTURE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
2. Ceiling mount with pendant mount with 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

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

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Emergency lighting units.
 - 2. Exit signs.
 - 3. Luminaire supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
 - 1. Include data on features, accessories, and finishes.
 - 2. Include physical description of the unit and dimensions.
 - 3. Battery and charger for light units.
 - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
 - 5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of luminaire.

B. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

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

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two year(s) from date of Substantial Completion.

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

- 1. Warranty Period for Emergency Power Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.
 - 2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. Comply with NEMA LE 4 for recessed luminaires.
- E. Comply with UL 1598 for fluorescent luminaires.
- F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.
- G. Bulb Shape: Complying with ANSI C79.1.
- H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.
 - 1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.

2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
 - b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
 - c. Humidity: More than 95 percent (condensing).
 - d. Altitude: Exceeding 3300 feet.
4. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Battery: Sealed, maintenance-free, nickel-cadmium type.
7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

2.2 EMERGENCY LIGHTING

- A. General Requirements for Emergency Lighting Units: Self-contained units.
- B. Emergency Luminaires:
 1. See Plans for manufacturers.
 2. Emergency Luminaires: as indicated on Interior Lighting Fixture Schedule, with the following additional features:
 - a. Operating at nominal voltage of 120 V ac or 277 V ac.
 - b. Internal emergency power unit.
 - c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.
- C. Emergency Lighting Unit:

1. See Plans for manufacturers.
2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. Two LED lamp heads.
7. Internal emergency power unit.

D. Remote Emergency Lighting Units:

1. See Plans for manufacturers.
2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. LED lamp heads.
7. External emergency power unit.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. See Plans for manufacturers.
2. Operating at nominal voltage of 120 V ac or 277 V ac.
3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
6. Master/Remote Sign Configurations:
 - a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply and battery for power connection to remote unit.
 - b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Prismatic acrylic.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. powder coat finish.

E. Conduit: Electrical metallic tubing or Flexible metallic conduit, minimum 3/4 inch in diameter.

2.5 METAL FINISHES

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire and emergency power unit weight.
 - 2. Able to maintain luminaire position when testing emergency power unit.
 - 3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
 - 2. Do not attach luminaires directly to gypsum board.
- F. Suspended Luminaire Support:
 - 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 - 3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
 - 4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- G. Ceiling Grid Mounted Luminaires:
 - 1. Secure to any required outlet box.
 - 2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
 - 3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Perform startup service:
 - 1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
 - 2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

- A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:
 - 1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
 - a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265219

SECTION 265619 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
- 2. Luminaire supports.

- B. Related Requirements:

- 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

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

- 1. Arrange in order of luminaire designation.
- 2. Include data on features, accessories, and finishes.
- 3. Include physical description and dimensions of luminaire.
- 4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
- 5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

- a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
 - 6. Wiring diagrams for power, control, and signal wiring.
 - 7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
 - B. LEED Submittals:
 - 1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
 - C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.
 - D. Delegated-Design Submittal: For luminaire supports.
 - 1. Include design calculations for luminaire supports.
- 1.5 INFORMATIONAL SUBMITTALS
- A. Product Certificates: For each type of the following:
 - 1. Luminaire.
 - B. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
 - C. Source quality-control reports.
 - D. Sample warranty.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
- 1.7 MAINTENANCE MATERIAL SUBMITTALS
- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.

3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. UL Compliance: Comply with UL 1598 and listed for wet location.
- D. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- E. Bulb shape complying with ANSI C79.1.
- F. CRI of minimum 70. CCT of 4000 K.
- G. L70 lamp life of 50,000 hours.
- H. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- I. Internal driver.
- J. Nominal Operating Voltage: 277 V ac.
- K. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.
- L. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

- A. Area and Site:
 - 1. See Plans for manufacturers.
 - 2. Luminaire Shape: Square.
 - 3. Mounting: Building.
 - 4. Luminaire-Mounting Height: As indicated on architectural plans.
 - 5. Distribution: Type IV.
 - 6. Diffusers and Globes: Prismatic acrylic.
 - 7. Housings:
 - a. Extruded-aluminum housing and heat sink.
 - b. powder-coat finish.

2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 - 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:
 - 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
 - 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.5 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- C. Factory-Applied Finish for Aluminum luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - 4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
 - a. Color: As indicated on plans.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Install lamps in each luminaire.
- C. Fasten luminaire to structural support.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
- F. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Adjust luminaires that require field adjustment or aiming.
- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

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

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes.
5. Signs.
6. Cable ties.
7. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

- C. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and TIA 606-B.
- B. Comply with ANSI Z535.4 for safety signs and labels.

- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 - 1. Black letters on a white field.
 - 2. Patch Panels.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Champion America.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
- B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester or vinyl flexible labels with acrylic pressure-sensitive adhesive.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. LEM Products Inc.
 - c. Marking Services, Inc.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 3. Marker for Labels: Permanent, waterproof black ink marker recommended by tag manufacturer.
 4. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester or Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
 2. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

- A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.

2.5 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. HellermannTyton.
 2. Ideal Industries, Inc.
 3. Marking Services, Inc.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black, except where used for color-coding.
- C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black.
- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
 3. UL 94 Flame Rating: 94V-0.
 4. Temperature Range: Minus 50 to plus 284 deg F.
 5. Color: Black.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.

- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- H. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
 - 3. Provide label 6 inches from cable end.
- I. Snap-Around Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches from cable end.
- J. Self-Adhesive Wraparound Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches from cable end.
- K. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
- L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- M. Underground-Line Warning Tape:
 - 1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [or concrete envelope] exceeds 16 inches overall.
 - 2. Limit use of underground-line warning tape to direct-buried cables.
 - 3. Install underground-line warning tape for direct-buried cables and cables in raceways.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
1. System legends shall be as follows:
 - a. Telecommunications.
- D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:
1. Wiring closet designation.
 2. Colon.
 3. Faceplate number.
- E. Equipment Room Labeling:
1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
 2. Patch Panels: Label individual rows and outlets, starting at top left and working down, with self-adhesive labels.
 3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
 - a. Room number being served.
 - b. Colon.
 - c. Faceplate number.
- F. Backbone Cables: Label each cable with a self-adhesive wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.
- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:

1. Room number.
 2. Colon.
 3. Faceplate number.
- H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
- I. Instructional Signs: Self-adhesive labels.
- J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Baked-enamel warning signs.
1. Apply to exterior of door, cover, or other access.
- K. Equipment Identification Labels:
1. Indoor Equipment: Self-adhesive label.
 2. Equipment to Be Labeled:
 - a. Communications cabinets.
 - b. Uninterruptible power supplies.
 - c. Computer room air conditioners.
 - d. Fire-alarm and suppression equipment.
 - e. Egress points.
 - f. Power distribution components.

END OF SECTION 270553

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Category 6 twisted pair cable.
2. Twisted pair cable hardware, including plugs and jacks.
3. Cabling identification products.
4. Grounding provisions for twisted pair cable.
5. Source quality control requirements for twisted pair cable.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. FTP: Shielded twisted pair.
- C. F/FTP: Overall foil screened cable with foil screened twisted pair.
- D. F/UTP: Overall foil screened cable with unscreened twisted pair.
- E. IDC: Insulation displacement connector.
- F. LAN: Local area network.
- G. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- H. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- I. RCDD: Registered Communications Distribution Designer.
- J. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- K. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- L. S/FTP: Overall braid screened cable with foil screened twisted pair.
- M. S/UTP: Overall braid screened cable with unscreened twisted pairs.

- N. UTP: Unscreened (unshielded) twisted pair.

1.4 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
 - 1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. Cabling administration Drawings and printouts.
 - 2. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.
- C. Twisted pair cable testing plan.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For installer, installation supervisor, and field inspector.
- B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faceplates: One of each type per school.
2. Jacks: 5 of each type per school.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications, Plenum Rated: Type CMP complying with UL 1685.
 - 2. Communications, Non-plenum: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- C. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden CDT Networking Division/NORDX.
 - 3. Draka USA.
- C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP).
- F. Cable Rating: Plenum.
- G. Jacket: Blue thermoplastic.

2.4 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden CDT Networking Division/NORDX.
 - 3. Draka USA.
- C. General Requirements for Twisted Pair Cable Hardware:
 - 1. Comply with the performance requirements of Category 6.
 - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 - 3. Cables shall be terminated with connecting hardware of same category or higher.
- D. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.
- E. Connecting Blocks:
 - 1. 110-style IDC for Category 6.
 - 2. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.
- F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
 - 1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 - 2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
 - 3. Number of Jacks per Field: One for each four-pair cable indicated.
- G. Jacks and Jack Assemblies:
 - 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Designed to snap-in to a patch panel or faceplate.
 - 3. Standard: Comply with TIA-568-C.2.
- H. Faceplate:

1. Two and Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Plastic Faceplate: High-impact plastic. Coordinate color with architect.
3. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.

I. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

2.5 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.6 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.7 SOURCE QUALITY CONTROL

- A. Factory test twisted pair cables according to TIA-568-C.2.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on

bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

- A. Comply with Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Comply with Section 260529 "Hangers and Supports for Electrical Systems."
- C. Drawings indicate general arrangement of pathways and fittings.

3.3 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
 - 2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
 - 5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
 - 9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - 10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 11. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
 - 12. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
- C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 36 inches apart.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Group connecting hardware for cables into separate logical fields.
- E. Separation from EMI Sources:
1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
 4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."

- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.5 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- D. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
 - b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.
- D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 271513

SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. 50/125-micrometer, multimode optical-fiber cabling.
 - 2. Fire alarm wire and cable.
 - 3. Identification products.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. IDC: Insulation displacement connector.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- E. RCDD: Registered Communications Distribution Designer.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of electronic safety and security cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Installation data for optical-fiber cables as specified in TIA 569-C-1.
- B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 1. Test optical-fiber cable to determine the continuity of the strand, end to end. Use optical-fiber flashlight or optical loss test set.
 2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length, and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

2.3 OPTICAL-FIBER CABLE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden Inc.
 - 3. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 4. CommScope, Inc.
 - 5. Corning Cable Systems.
 - 6. Draka Cableteq USA; a Prysmian Group company.
 - 7. General Cable Technologies Corporation.
 - 8. Mohawk; a division of Belden Networking, Inc.
 - 9. Superior Essex Inc.
 - 10. West Penn Wire.
- B. Description: Multimode, 50/125-micrometer, 24-fiber, non-conductive, tight buffer, optical-fiber cable.
 - 1. Comply with ICEA S-83-596 for mechanical properties.
 - 2. Comply with TIA-568-C.3 for performance specifications.
 - 3. Comply with TIA-492AAAB for detailed specifications.
 - 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - a. General Purpose, Nonconductive: Type OFN or Type OFNG, or Type OFNR, Type OFNP.
 - b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - c. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.
 - 5. Conductive cable shall be aluminum armored type.
 - 6. Maximum Attenuation: 3.50 db/km at 850 nm; 1.5 db/km at 1300 nm.
 - 7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
- C. Jacket:
 - 1. Jacket Color: Aqua for 50/125-micrometer cable.
 - 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.4 OPTICAL-FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M.
 2. ADC.
 3. American Technology Systems Industries, Inc.
 4. AMP NETCONNECT; a TE Connectivity Ltd. company.
 5. Belden Inc.
 6. Berk-Tek Leviton; a Nexans/Leviton alliance.
 7. Corning Cable Systems.
 8. Hubbell Incorporated.
 9. Leviton Manufacturing Co., Inc.
 10. Molex Premise Networks.
 11. West Penn Wire.
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.
- D. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standard (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA-604-12. Comply with TIA-568-C.3.
1. Quick-connect, simplex and duplex, Type SC, Type ST, Type LC or Type MT-RJ connectors. Insertion loss not more than 0.75 db.
 2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.5 FIRE ALARM WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Allied Wire & Cable Inc.
 2. CommScope, Inc.
 3. Comtran Corporation.
 4. Draka Cableteq USA; a Prysmian Group company.
 5. Genesis Cable Products; Honeywell International, Inc.
 6. Rockbestos-Suprenant Cable Corp.
 7. Superior Essex Inc.
 8. West Penn Wire.

- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, not less than 16 AWG.
 - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 - 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NRTL listed for fire alarm and cable tray installation, plenum rated.

2.6 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Brady Corporation.
 - 2. HellermannTyton.
 - 3. Kroy LLC.
 - 4. Panduit Corp.
- B. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

- A. Factory test optical-fiber cables on reels according to TIA-568-C.1.
- B. Factory test multimode optical fiber cables according to TIA-526.14-B and TIA-568-C.3.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

- A. Install wiring in metal pathways and wireways.
 - 1. Minimum conduit size shall be 3/4 inch. Control and data-transmission wiring shall not share conduits with other building wiring systems.
- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring on Racks and within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM's "Cabling Termination Practices" chapter. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.
 - 2. Install lacing bars and distribution spools.
 - 3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
 - 4. Install conductors parallel with or at right angles to sides and back of enclosure.
 - 5. Connect conductors associated with intrusion system that are terminated, spliced, or interrupted in any enclosure onto terminal blocks.
 - 6. Mark each terminal according to system's wiring diagrams.
 - 7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1 and NFPA 70.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
- D. Install UTP, optical-fiber, and coaxial cables and connecting materials after spaces are complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- E. General Requirements for Cabling:

1. Comply with TIA-568-C.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels. Leave a minimum of 6 inches of slack at outlet terminations and coil loosely into box after termination on outlet fitting.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Maintain minimum cable bending radius during installation and termination of cables.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions. Do not exceed manufacturer's rated cable-pulling tension.
9. Riser Cable: Riser cable support intervals shall be in accordance with manufacturer's recommendations.
10. Comply with Section 280544 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

F. Optical-Fiber Cable Installation:

1. Comply with TIA-568-C.3.
2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

G. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart. Cable supports shall be fastened to structural members or floor slabs in accordance with Section 260529 "Hangers and Supports for Electrical Systems."
3. Cable shall not be run in contact with pipes, ducts, or other potentially damaging items. Cables shall not be run through structural members or use structural members, pipes, ducts, or equipment as a support.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-C recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communication cables or cables in nonmetallic pathways and unshielded power conductors and electrical equipment shall be as follows:

- a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communication cables in grounded metallic pathways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between cables in grounded metallic pathways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or hp and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method:
 1. Install plenum cable in environmental air spaces, including plenum ceilings. Plenum rated cable is permitted to be used throughout the building.
 2. Cables and pathways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 3. Fire-Rated Cables: Use of two-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
 4. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or pathway as signaling line circuits.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

- E. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and another for supervisory circuits. Color code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- F. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
- G. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 POWER AND CONTROL-CIRCUIT CONDUCTORS

- A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
- B. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits, No. 14 AWG.
 - 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
 - 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.6 CONNECTIONS

- A. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-C, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

- A. For communication wiring, comply with J-STD-607-A and with BICSI TDMM's "Grounding, Bonding, and Electrical Protection" chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Section 280526 "Grounding and Bonding for Electronic Safety and Security."

3.9 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Visually inspect UTP and optical-fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
 - a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 4. Optical-Fiber Cable Tests:
 - a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
 - 2) Attenuation test results for links shall be less than 2.0 db. Attenuation test results shall be less than that calculated according to equation in TIA-568-C.1.
- C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 280513

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fire-alarm control unit.
 - 2. Manual fire-alarm boxes.
 - 3. System smoke detectors.
 - 4. Heat detectors.
 - 5. Notification appliances.
 - 6. Magnetic door holders.
 - 7. Remote annunciator.
 - 8. Addressable interface device.
 - 9. Digital alarm communicator transmitter.
 - 10. Network communications.

1.3 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
 - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 - b. Show field wiring required for HVAC unit shutdown on alarm.
 - c. Locate detectors according to manufacturer's written recommendations.
12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified, fire-alarm technician; Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.

2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field quality-control reports.

1.6 Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:
 - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
 - d. Riser diagram.
 - e. Device addresses.
 - f. Record copy of site-specific software.
 - g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
 - h. Manufacturer's required maintenance related to system warranty requirements.
 - i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.
- B. Software and Firmware Operational Documentation:

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

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
 2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
 3. Smoke Detectors, Heat Detectors, and Carbon Monoxide Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
 4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
 5. Keys and Tools: One extra set for access to locked or tamperproofed components.
 6. Audible and Visual Notification Appliances: One of each type installed.
 7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
 8. Provide all necessary hardware and programming to provide the client with 20% spare capacity on all initiating and indicating circuits.
 9. Provide as part of the base contract all labor and materials to install twenty (20) additional fire alarm devices during construction. The twenty (20) fire alarm device can be but not limited to smoke detector, heat detector, door holder, duct detector, fan shutdown, tamper switches, flow switches, etc. Include all labor and materials including wire, boxes, conduit, terminations, hardware, software, programming and testing.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.10 PROJECT CONDITIONS

- A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions

and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
 2. Do not proceed with interruption of fire-alarm service without Owner's written permission.
- B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

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

1.12 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.

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

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices:
 - 1. Manual stations.
 - 2. Heat detectors.
 - 3. Smoke detectors.
 - 4. Duct smoke detectors.
 - 5. Fire-extinguishing system operation.
- B. Fire-alarm signal shall initiate the following actions:
 - 1. Continuously operate alarm notification appliances, including voice evacuation notices.
 - 2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
 - 3. Transmit an alarm signal to the remote alarm receiving station.
 - 4. Unlock electric door locks in designated egress paths.
 - 5. Release fire and smoke doors held open by magnetic door holders.
 - 6. Activate voice/alarm communication system.
 - 7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 - 8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - 9. Recall elevators to primary or alternate recall floors.
 - 10. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
 - 1. Carbon monoxide detector.
 - 2. Independent fire-detection and –suppression systems.
 - 3. User disabling of zones or individual devices.
 - 4. Loss of communication with any panel on the network.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
 - 1. Open circuits, shorts, and grounds in designated circuits.
 - 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - 3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, or Ethernet module.
 - 4. Loss of primary power at fire-alarm control unit.
 - 5. Ground or a single break in internal circuits of fire-alarm control unit.

6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

F. Signal from carbon monoxide detector shall initiate the following actions:

1. Initiate supervisory signal to system and records at the main panel and remote annunciator.
2. Transmits a (supervisory) carbon monoxide signal to central station.
3. Continuously operate sounder base associated with the carbon monoxide detector.

2.3 FIRE-ALARM CONTROL UNIT

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

1. Gamewell - FCI by Honeywell.
2. GE UTC Fire & Security; A United Technologies Company.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder.
 - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
 - d. The FACP shall be listed for connection to a central-station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to

initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
 3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
- D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
1. Pathway Class Designations: NFPA 72, Class B.
 2. Pathway Survivability: Level 0.
 3. Install no more than 100 addressable devices on each signaling-line circuit.
 4. Serial Interfaces:
 - a. One dedicated RS 485 port for central-station operation using point ID DACT.
 - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
 - c. One USB port for PC configuration.
- E. Notification-Appliance Circuit:
1. FIRE ALARM: Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
 2. CARBON MONOXIDE ALARM: Audible appliances shall sound in a four-pulse temporal pattern, as defined in NFPA 72, or a constant tone. Carbon monoxide alarm sound shall be different than the fire alarm sound.
 3. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
 4. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- F. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
 - a. Elevator lobby detectors except the lobby detector on the designated floor.
 - b. Smoke detector in elevator machine room.
 - c. Smoke detectors in elevator hoistway.
 2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
- G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to the fire-alarm system.
- H. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values.
- I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- J. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
 - a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
 - b. Programmable tone and message sequence selection.
 - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
 - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
 2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
 3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
- K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory

signals and supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Sealed lead calcium.
- M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Gamewell - FCI by Honeywell.
 2. GE UTC Fire & Security; A United Technologies Company.
 3. Notifier.
 4. Siemens Industry, Inc.; Fire Safety Division.
 5. System Sensor.
 6. Wheelock; a brand of Eaton.
- B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 2. Station Reset: Key- or wrench-operated switch.
 3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.5 SYSTEM SMOKE DETECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Gamewell - FCI by Honeywell.
 2. GE UTC Fire & Security; A United Technologies Company.

3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. Multiple levels of detection sensitivity for each sensor.
 - b. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

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

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

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

3. Each sensor shall have multiple levels of detection sensitivity.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.6 PROJECTED BEAM SMOKE DETECTORS

- A. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.
- B. Detector Address: Accessible from fire-alarm control unit and able to identify the detector's location within the system and its sensitivity setting.
- C. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 1. Primary status.
 2. Device type.
 3. Present average value.
 4. Present sensitivity selected.
 5. Sensor range (normal, dirty, etc.).

2.7 CARBON MONOXIDE DETECTORS

- A. General: Carbon monoxide detector listed for connection to fire-alarm system.
 1. Mounting: Adapter plate for outlet box mounting.
 2. Testable by introducing test carbon monoxide into the sensing cell.
 3. Detector shall provide alarm contacts and trouble contacts.
 4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
 5. Comply with UL 2075.
 6. Locate, mount, and wire according to manufacturer's written instructions.
 7. Provide means for addressable connection to fire-alarm system.
 8. Test button simulates an alarm condition.
 9. Provide with sounder bases for local audio annunciation.

2.8 MULTICRITERIA DETECTORS

- A. Mounting: Twist-lock base interchangeable with smoke-detector bases.
- B. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- C. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. The detector shall send trouble alarm if it is incapable of compensating for existing conditions.
- D. Test button tests all sensors in the detector.

- E. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - 1. Primary status.
 - 2. Device type.
 - 3. Present sensitivity selected.
 - 4. Sensor range (normal, dirty, etc.).
- F. Sensors: The detector shall be comprised of four sensing elements including a smoke sensor, a carbon monoxide sensor, an infrared sensor, and a heat sensor.
 - 1. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.
 - 2. Carbon monoxide sensor shall be as described in "Carbon Monoxide Detectors" Article.
 - 3. Heat sensor shall be as described in "Heat Detectors" Article.
 - 4. Each sensor shall be separately listed according to requirements for its detector type.

2.9 HEAT DETECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Gamewell - FCI by Honeywell.
 - 2. GE UTC Fire & Security; A United Technologies Company.
 - 3. Notifier.
 - 4. Siemens Industry, Inc.; Fire Safety Division.
- B. General Requirements for Heat Detectors: Comply with UL 521.
 - 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
 - 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.10 NOTIFICATION APPLIANCES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. GE UTC Fire & Security; A United Technologies Company.
 - 2. Siemens Industry, Inc.; Fire Safety Division.
 - 3. System Sensor.

4. Wheelock; a brand of Eaton.
- B. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
- D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall mounted unless otherwise indicated.
 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 4. Flashing shall be in a temporal pattern, synchronized with other units.
 5. Strobe Leads: Factory connected to screw terminals.
 6. Mounting Faceplate:
 - a. Fire alarm unit: Factory finished, red with "FIRE" in white letters.
 - b. Carbon monoxide unit: Factory finished, white with "CARBON MONOXIDE" in blue letters. Provide with blue lens.
- E. Voice/Tone Notification Appliances:
1. Comply with UL 1480.
 2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
 3. High-Range Units: Rated 2 to 15 W.
 4. Low-Range Units: Rated 1 to 2 W.
 5. Mounting: Flush.
 6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.11 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

B. Material and Finish: Match door hardware.

2.12 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s),

signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.15 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
 1. Connect new equipment to existing control panel in existing part of the building.
 2. Connect new equipment to existing monitoring equipment at the supervising station.
 3. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
- D. Manual Fire-Alarm Boxes:
 1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
 2. Mount manual fire-alarm box on a background of a contrasting color.
 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- E. Smoke- or Heat-Detector Spacing:
 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.

2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 3. Smooth ceiling spacing shall not exceed 30 feet.
 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
 5. HVAC: Locate detectors not closer than 60 inches from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- I. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- K. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- 3.3 PATHWAYS
- A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.
1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.
- B. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

- A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Smoke dampers in air ducts of designated HVAC duct systems.
 - 2. Magnetically held-open doors.
 - 3. Electronically locked doors and access gates.
 - 4. Alarm-initiating connection to elevator recall system and components.

3.5 IDENTIFICATION

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

3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

3.8 DEMONSTRATION

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

END OF SECTION 283111