

**BOOK 3 – VOLUME 2
TECHNICAL SPECIFICATIONS
DIVISIONS 21 - 33**

CONTRACT NO. CXXXX

**MALCOLM X COLLEGE
WEST SIDE LEARNING CENTER
ADDITION AND RENOVATION
4625 W. MADISON STREET
CHICAGO, IL 60644**

**NEW CONSTRUCTION/RENOVATIONS
PBC PROJECT #03720**

PUBLIC BUILDING COMMISSION OF CHICAGO



**Mayor Brandon Johnson
Chairman**

Carina E. Sánchez
Executive Director

Room 200
Richard J. Daley Center
50 West Washington Street
Chicago, Illinois 60602
312-744-3090
www.pbcchicago.com

**75%CD Draft for CM Procurement – Not For Construction
March 13, 2024**

By
BAILEY EDWARD
35 E WACKER DRIVE
CHICAGO, IL 60601
312.440.2300



SPECIFICATIONS TABLE OF CONTENTS

MALCOLM X COLLEGE - WEST SIDE LEARNING CENTER

TABLE OF CONTENTS

VOLUME 1

DIVISION 1

SECTION 00 01 11	SUPPLEMENTAL PROJECT INFORMATION
SECTION 01 10 00	SUMMARY
SECTION 01 20 00	PAYMENT AND CONTRACT MODIFICATION PROCEDURES
SECTION 01 25 00	SUBSTITUTION PROCEDURES
SECTION 01 25 00.01	SUBSTITUTION REQUEST FORM
SECTION 01 26 00	CONTRACT MODIFICATION PROCEDURES
SECTION 01 31 00	PROJECT MANAGEMENT AND COORDINATION
SECTION 01 32 00	CONSTRUCTION PROGRESS DOCUMENTATION
SECTION 01 33 00	SUBMITTAL PROCEDURES
SECTION 01 33 29	LEED SUSTAINABLE DESIGN REPORTING
SECTION 01 33 29.04	LEED MATERIAL CONTENT FORM
SECTION 01 33 29.07	LEED PROHIBITED CONTENT INSTALLER CERTIFICATION
SECTION 01 40 00	QUALITY REQUIREMENTS
SECTION 01 43 39	INTEGRATED EXTERIOR MOCKUPS
SECTION 01 50 00	TEMPORARY FACILITIES
SECTION 01 50 10	COMMISSION REPRESENTATIVE FIELD OFFICE
SECTION 01 56 39	TEMP TREE AND PLANT PROTECTION
SECTION 01 57 13	LEED TEMPORARY EROSION AND SEDIMENT CONTROL
SECTION 01 57 19	LEED INDOOR AIR QUALITY CONTROLS
SECTION 01 60 00	PRODUCT REQUIREMENTS
SECTION 01 61 16	LEED VOLATILE ORGANIC COMPOUND VOC CONTENT RESTRICTIONS
SECTION 01 64 00	OWNER-FURNISHED PRODUCTS
SECTION 01 64 00.1	AV EQUIPMENT SCHEDULE
SECTION 01 64 00.2	SECURITY EQUIPMENT SCHEDULE
SECTION 01 73 00	EXECUTION REQUIREMENTS
SECTION 01 73 29	CUTTING AND PATCHING
SECTION 01 74 13	CONSTRUCTION CLEANING
SECTION 01 74 19	LEED CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
SECTION 01 74 23	FINAL CLEANING
SECTION 01 77 00	PROJECT CLOSE-OUT
SECTION 01 78 23	OPERATING AND MAINTENANCE DATA
SECTION 01 78 39	PROJECT RECORD DOCUMENTS
SECTION 01 79 00	DEMONSTRATION AND TRAINING
SECTION 01 81 09	LEED TESTING FOR INDOOR AIR QUALITY
SECTION 01 83 16	BUILDING ENCLOSURE FIELD TESTING
SECTION 01 91 13	GENERAL COMMISSIONING REQUIREMENTS
SECTION 01 91 13.1	BUILDING SYSTEMS COMMISSIONING PLAN

DIVISION 2

SECTION 02 13 15	SMALL SCALE DISTURBANCE OF ASBESTOS CONTAINING MATERIALS
SECTION 02 41 16	STRUCTURE DEMOLITION
SECTION 02 41 18	PAVEMENT REMOVAL
SECTION 02 41 19	SELECTIVE STRUCTURE DEMOLITION



SPECIFICATIONS TABLE OF CONTENTS

SECTION 02 82 13
SECTION 02 83 19
SECTION 02 86 13

DIVISION 3

SECTION 03 30 00
SECTION 03 92 50

DIVISION 4

SECTION 04 20 00

DIVISION 5

SECTION 05 12 00
SECTION 05 21 00
SECTION 05 31 10
SECTION 05 40 00
SECTION 05 50 00
SECTION 05 73 13

DIVISION 6

SECTION 06 10 00
SECTION 06 20 23
SECTION 06 41 13
SECTION 06 41 16
SECTION 06 42 16

DIVISION 7

SECTION 07 14 16
SECTION 07 21 00
SECTION 07 26 00
SECTION 07 27 26
SECTION 07 42 13.16
SECTION 07 52 16.11
SECTION 07 52 16.12
SECTION 07 62 00
SECTION 07 72 00
SECTION 07 81 23
SECTION 07 84 13
SECTION 07 91 00
SECTION 07 92 00
SECTION 07 95 00

DIVISION 8

SECTION 08 11 13
SECTION 08 14 16
SECTION 08 17 13
SECTION 08 41 13
SECTION 08 41 23
SECTION 08 44 13
SECTION 08 44 18

ASBESTOS ABATEMENT – PRIOR TO DEMOLITION
LEAD-BASED PAINT ABATEMENT
HAZARDOUS AND UNIVERSAL WASTE MANAGEMENT

CONCRETE

CAST-IN-PLACE CONCRETE
CONCRETE RESURFACING

MASONRY

UNIT MASONRY

METALS

STRUCTURAL STEEL FRAMING
STEEL JOIST FRAMING
STEEL DECKING
COLD-FORMED METAL FRAMING
METAL FABRICATIONS
GLAZED DECORATIVE METAL RAILINGS

WOOD AND PLASTICS

ROUGH CARPENTRY
INTERIOR FINISH CARPENTRY
WOOD-VENEER-FACED ARCHITECTURAL CABINETS
PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS
FLUSH WOOD PANELING

THERMAL AND MOISTURE PROTECTION

COLD-FLUID-APPLIED WATERPROOFING
THERMAL INSULATION
UNDER-SLAB VAPOR BARRIER
FLUID-APPLIED MEMBRANE AIR BARRIERS
METAL PLATE WALL PANELS
COLD APPLIED MODIFIED BITUMINOUS MEMBRANE ROOFING
HOT APPLIED MODIFIED BITUMINOUS MEMBRANE ROOFING
SHEET METAL FLASHING AND TRIM
ROOF ACCESSORIES
INTUMESCENT FIREPROOFING
PENETRATION FIRESTOPPING
PREFORMED JOINT SEALS
JOINT SEALANTS
EXPANSION CONTROL

DOORS AND WINDOWS

HOLLOW METAL DOORS AND FRAMES
FLUSH WOOD DOORS
INTEGRATED METAL DOOR OPENING ASSEMBLIES
ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
FIRE RATED ALUMINUM FRAMED ENTRANCES AND STOREFRONTS
GLAZED ALUMINUM CURTAIN WALLS
GLAZED STEEL CURTAIN WALLS



SPECIFICATIONS TABLE OF CONTENTS

SECTION 08 71 00
SECTION 08 71 00.1

SECTION 08 80 00
SECTION 08 83 00

DIVISION 9

SECTION 09 29 00
SECTION 09 30 13
SECTION 09 51 13
SECTION 09 54 23
SECTION 09 65 13
SECTION 09 65 16
SECTION 09 65 36
SECTION 09 68 13
SECTION 09 72 00
SECTION 09 91 23
SECTION 09 93 00

DIVISION 10

SECTION 10 14 19
SECTION 10 21 13.17
SECTION 10 22 26
SECTION 10 26 00
SECTION 10 28 00
SECTION 10 44 00

DIVISION 11

SECTION 11 01 90

DIVISION 12

SECTION 12 11 12
SECTION 12 36 61.19

VOLUME 2

DIVISION 21

SECTION 21 13 13

DIVISION 22

SECTION 22 05 13
SECTION 22 05 16
SECTION 22 05 17
SECTION 22 05 18
SECTION 22 05 19
SECTION 22 05 23
SECTION 22 05 29
SECTION 22 05 53
SECTION 22 07 19
SECTION 22 11 13
SECTION 22 11 16
SECTION 22 11 19

DOOR HARDWARE
DOOR HARDWARE SET LIST

GLAZING

MIRRORS

FINISHES

GYPSUM BOARD SYSTEMS
CERAMIC TILING
ACOUSTICAL PANEL CEILINGS
LINEAR METAL CEILINGS
RESILIENT BASE AND ACCESSORIES
RESILIENT SHEET FLOORING
STATIC-CONTROL RESILIENT FLOORING
TILE CARPETING
WALL COVERINGS
INTERIOR PAINTING
STAINING AND TRANSPARENT FINISHING

SPECIALTIES

DIMENSIONAL LETTER SIGNAGE
PHENOLIC-CORE TOILET COMPARTMENTS
OPERABLE PARTITIONS
WALL AND DOOR PROTECTION
TOILET, BATH, AND LAUNDRY ACCESSORIES
FIRE EXTINGUISHERS CABINETS AND ACCESSORIES

EQUIPMENT

ROOF FALL PROTECTION

FURNISHINGS

MANUAL AND ELEC INTELLIGENT ROLLER SHADE SYSTEM
QUARTZ AGGLOMERATE COUNTERTOPS

FIRE SUPPRESSION

WET-PIPE SPRINKLER SYSTEMS

PLUMBING

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
EXCUTCHEONS FOR PLUMBING PIPING
METERS AND GAGES FOR PLUMBING PIPING
GENERAL DUTY VALVES
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
DOMESTIC WATER PIPING INSULATION
FACILITY WATER DISTRIBUTION PIPING
DOMESTIC WATER PIPING
DOMESTIC WATER PIPING SPECIALTIES



SPECIFICATIONS TABLE OF CONTENTS

SECTION 22 13 16
SECTION 22 13 19
SECTION 22 13 19.13
SECTION 22 13 23
SECTION 22 14 13
SECTION 22 14 23
SECTION 22 34 00
SECTION 22 42 13.13
SECTION 22 42 13.16
SECTION 22 42 16.13
SECTION 22 42 16.16
SECTION 22 47 13

DIVISION 23

SECTION 23 05 13
SECTION 23 05 16
SECTION 23 05 17
SECTION 23 05 18
SECTION 23 05 19
SECTION 23 05 29
SECTION 23 05 48
SECTION 23 05 53
SECTION 23 05 93
SECTION 23 07 13
SECTION 23 07 19
SECTION 23 08 00
SECTION 23 09 23
SECTION 23 09 23.16
SECTION 23 09 23.19
SECTION 23 09 23.21
SECTION 23 09 23.23
SECTION 23 09 23.27
SECTION 23 11 23
SECTION 23 21 13
SECTION 23 21 16
SECTION 23 21 23
SECTION 23 23 00
SECTION 23 31 13
SECTION 23 33 00
SECTION 23 33 46
SECTION 23 36 00
SECTION 23 37 13
SECTION 23 51 23
SECTION 23 74 33
SECTION 23 81 29
SECTION 23 82 39.19

DIVISION 26

SECTION 26 01 26
SECTION 26 05 00

SANITARY WASTER AND VENT PIPING
SANITARY WASTER PIPING SPECIALTIES
SANITARY DRAINS
SANITARY WASTE INTERCEPTORS
FACILITY STORM DRAINAGE PIPING
STORM DRAINAGE PIPING SPECIALTIES
FUEL-FIRES, DOMESTIC-WATER HEATERS
COMMERCIAL WATER CLOSETS
COMMERCIAL URINALS
COMMERCIAL LAVATORIES
COMMERCIAL SINKS
DRINKING FOUNTAINS

HEATING VENTILATION AND AIR CONDITIONING

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
EXCUTCHEONS FOR HVAC PIPING
METERS AND GAGES FOR HVAC PIPING
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
VIBRATION CONTROLS FOR HVAC
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
TESTING, ADJUSTING, AND BALANCING FOR HVAC
DUCT INSULATION
HVAC PIPING INSULATION
HVAC COMMISSIONING
DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
GAS INSTRUMENTS
MOISTURE INSTRUMENTS
MOTION INSTRUMENTS
PRESSURE INSTRUMENTS
TEMPERATURE INSTRUMENTS
FACILITY NATURAL-GAS PIPING
HYDRONIC PIPING
HYDRONIC PIPING SPECIALTIES
HYDRONIC PUMPS
REFRIGERANT PIPING
METAL DUCTS
AIR DUCT ACCESSORIES
FLEXIBLE DUCTS
AIR TERMINAL UNITS
DIFFUSERS, REGISTERS, AND GRILLES
GAS VENTS
DEDICATED OUTDOOR-AIR UNITS
VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS
WALL AND CEILING UNIT HEATERS

ELECTRICAL

TESTING ELECTRICAL SYSTEM
GENERAL ELECTRICAL PROVISIONS



SPECIFICATIONS TABLE OF CONTENTS

SECTION 26 05 01	ELECTRICAL DEMOLITION AND ALTERATIONS
SECTION 26 05 19	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
SECTION 26 05 26	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
SECTION 26 05 29	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
SECTION 26 05 33	RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
SECTION 26 05 53	IDENTIFICATION FOR ELECTRICAL SYSTEMS
SECTION 26 05 73	OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY
SECTION 26 09 23	LIGHTING CONTROL DEVICES
SECTION 26 09 43	RELAY-BASED LIGHTING CONTROLS
SECTION 26 24 16	PANELBOARDS
SECTION 26 27 02	EQUIPMENT CONNECTIONS
SECTION 26 27 26	WIRING DEVICES
SECTION 26 28 13	FUSES
SECTION 26 28 16	ENCLOSED SWITCHES AND CIRCUIT BREAKERS
SECTION 26 51 19	INTERIOR LIGHTING
SECTION 26 56 00	EXTERIOR LIGHTING
DIVISION 27	COMMUNICATIONS
SECTION 27 05 26	GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS
SECTION 27 05 28	PATHWAYS FOR COMMUNICATIONS SYSTEMS
SECTION 27 60 00	SYSTEM ROUGH-IN REQUIREMENTS
DIVISION 28	ELECTRONIC SAFETY AND SECURITY
SECTION 28 31 00	ADDRESSABLE FIRE-ALARM DETECTION SYSTEMS
DIVISION 31	EARTHWORK
SECTION 31 10 00	SITE CLEARING
SECTION 31 20 00	EARTH MOVING
SECTION 31 29 08	FINAL SHAPING, GRADING AND SITE RESTORATION
DIVISION 32	EXTERIOR IMPROVEMENTS
SECTION 32 12 16	ASPHALT PAVING
SECTION 32 12 36	ASPHALT SEALCOAT
SECTION 32 13 13	CONCRETE PAVING
SECTION 32 17 23.13	PAINTED PAVEMENT MARKINGS
SECTION 32 31 19	DECORATIVE METAL FENCES AND GATES
SECTION 32 33 00	SITE FURNISHINGS
SECTION 32 35 00	ADA TILE
SECTION 32 91 00	TEMPORARY SOIL EROSION CONTROL
SECTION 32 92 00	TURF AND GRASSES
SECTION 32 93 00	EXTERIOR PLANTS AND SOIL
DIVISION 33	UTILITIES
SECTION 33 05 17	SEWER STRUCTURES
SECTION 33 10 00	WATER UTILITIES
SECTION 33 22 05	AGGREGATE BASE COURSE
SECTION 33 30 00	SANITARY AND STORM SEWERAGE
SECTION 33 47 00	ADJUSTMENT AND REPAIR OF EXISTING UTILITY STRUCTURES
APPENDIX A	GEOTECHNICAL REPORT



SPECIFICATIONS TABLE OF CONTENTS

APPENDIX B

HAZARDOUS MATERIALS REPORT

END OF TABLE OF CONTENTS

SECTION 21 13 13 - WET-PIPE SPRINKLER 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. Pipes, fittings, and specialties.
 - 2. Cover system for sprinkler piping.
 - 3. Specialty valves.
 - 4. Fire Department Connections
 - 5. Sprinklers.
 - 6. Alarm devices.
 - 7. Manual control stations.
 - 8. Control panels.
 - 9. Pressure gages.

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

- A. Shop Drawings: For wet-pipe sprinkler systems.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.
- B. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Coordination Drawings: Sprinkler systems, drawn to scale, on which the items are shown and coordinated with each other, using input from installers of the items involved.
- D. Design Data:
 - 1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

E. Field Test Reports:

1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
2. Fire-hydrant flow test report.

F. Field quality-control reports.

G. Contractor shall be responsible for providing design drawings as required of authorities having jurisdiction. The plans shall be submitted for approval to the authorities having jurisdiction before any equipment is installed.

H. As-Built Drawings:

1. Upon completion of the installation, the Contractor shall revise all Fire Protection Design files, calculations, manuals, operating instructions to agree with the construction as actually accomplished. The notation "As Built" shall be entered in the revision block, dated and initialed. All as-built records will follow the requirements listed under this article.
2. The as-built files shall show the entire water extinguishing systems upon incorporating changes made in field and submit to Architect for Owner's record.
3. Final hydraulic calculations shall reflect the "As-Built" condition. These calculations must be submitted before final acceptance and testing.

I. After completing a sprinkler system installation, the Contractor shall submit to the authority having jurisdiction a written certification that the system has been installed in accordance with the approved plans and tested in accordance with NFPA-13.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, 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. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
 - B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.
- 1.8 ETRAC MATERIALS
- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on the Project.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 1. NFPA 13.
- B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
 1. Sprinkler system design shall be approved by authorities having jurisdiction.

2.2 STEEL PIPE AND FITTINGS

- A. Standard-Weight, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 30, Black-Steel Pipe: ASTM A 135/A 135M; ASTM A 795/A 795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
- C. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

- D. Malleable- or Ductile-Iron Unions: UL 860.
- E. Cast-Iron Flanges: ASME 16.1, Class 125.
- F. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
 - 1. Pipe-Flange Gasket Materials: B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
 - a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
 - b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
 - 2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
- G. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
 - 1. 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.
- H. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Tyco by Johnson Controls Company.
 - c. Victaulic Company.
 - 2. Pressure Rating: 175-psig minimum.
 - 3. Painted Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating:
 - 1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
- C. Body Material: Cast or ductile iron.
- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Alarm Valves:
 - 1. Standard: UL 193.

2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, and fill-line attachment with strainer.
4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
6. 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.

G. Automatic (Ball Drip) Drain Valves:

1. Standard: UL 1726.
2. Pressure Rating: 175-psig minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4.
5. End Connections: Threaded.

2.4 FIRE-DEPARTMENT CONNECTIONS

A. Exposed-Type, Fire Department Connection

1. Standard: UL 405.
2. Pressure Rating: 175-psig minimum.
3. Type: Exposed, projecting, for wall mounting.
4. Body Material: Corrosion-resistant metal.
5. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
6. Caps: Brass, lugged type, with gasket and chain.
7. Escutcheon Plate: Round, brass, wall type.
8. Outlet: Back, with pipe threads.
9. Number of Inlets: Two minimum, verify with local authority having jurisdiction.
10. Escutcheon Plate Marking: Similar to "AUTO SPKR".
11. Finish: Verify with Architect and Owner.
12. Outlet Size: NPS 4.

2.5 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 175-psig minimum.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Standard: UL 199.
2. Pressure Rating: 175 psig.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Standard: UL 1474.
2. Pressure Rating: 250-psig minimum.
3. Body Material: Steel pipe with EPDM-rubber O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Standard: UL 1474.
2. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: 175-psig minimum.
4. Size: Same as connected piping, for sprinkler.

2.6 SPRINKLERS

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating for Residential Sprinklers: 175-psig maximum.
- C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.
- D. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
 2. Nonresidential Applications: UL 199.
 3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- E. Open Sprinklers with Heat-Responsive Element Removed: UL 199.
1. Nominal Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8.
 2. Nominal Orifice: 17/32 inch with discharge coefficient K between 7.4 and 8.2.
- F. Sprinkler Finishes: Chrome plated in finished areas, bronze in unfinished areas.
- G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting: Plastic, white finish, one piece, flat.
 2. Sidewall Mounting: Plastic, white finish, one piece, flat.
- H. Sprinkler Guards:
1. Standard: UL 199.
 2. Type: Wire cage with fastening device for attaching to sprinkler.
- 2.7 ALARM DEVICES
- A. Alarm-device types shall match piping and equipment connections.
- B. Water-Motor-Operated Alarm:
1. Standard: UL 753.
 2. Type: Mechanically operated, with Pelton wheel.
 3. Alarm Gong: Cast aluminum with red-enamel factory finish.
 4. Size: 8-1/2-inches diameter.
 5. Components: Shaft length, bearings, and sleeve to suit wall construction.
 6. Inlet: NPS 3/4.
 7. Outlet: NPS 1 drain connection.
- C. Electrically Operated Alarm Bell:
1. Standard: UL 464.
 2. Type: Vibrating, metal alarm bell.
 3. Size: 6-inch minimum-diameter.
 4. Finish: Red-enamel factory finish, suitable for outdoor use.
 5. 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. Water-Flow Indicators:
1. Standard: UL 346.
 2. Water-Flow Detector: Electrically supervised.

3. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
4. Type: Paddle operated.
5. Pressure Rating: 250 psig.
6. Design Installation: Horizontal or vertical.

E. Pressure Switches:

1. Standard: UL 346.
2. Type: Electrically supervised water-flow switch with retard feature.
3. Components: Single-pole, double-throw switch with normally closed contacts.
4. Design Operation: Rising pressure signals water flow.

F. Valve Supervisory Switches:

1. Standard: UL 346.
2. Type: Electrically supervised.
3. Components: Single-pole, double-throw switch with normally closed contacts.
4. Design: Signals that controlled valve is in other than fully open position.
5. 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.

2.8 MANUAL CONTROL STATIONS

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve.
- B. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.9 CONTROL PANELS

- A. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves.
 1. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" when used with thermal detectors and Class A detector circuit wiring.
 2. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
 3. 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. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.
- C. Manual Control Stations: Hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

D. Panels Components:

1. Power supply.
2. Battery charger.
3. Standby batteries.
4. Field-wiring terminal strip.
5. Electrically supervised solenoid valves and polarized fire-alarm bell.
6. Lamp test facility.
7. Single-pole, double-throw auxiliary alarm contacts.
8. Rectifier.

2.10 PRESSURE GAGES

- A. Standard: UL 393.
- B. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- C. Pressure Gage Range: 0- to 250-psig minimum.
- D. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
- B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building. Install water service piping per NFPA 13.
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 WATER-SUPPLY CONNECTIONS

- A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping.

- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.4 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
 - 2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.
- C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- J. Install alarm devices in piping systems.
- K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- M. Fill sprinkler system piping with water.
- N. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing.
- O. Install sleeves for piping penetrations of walls, ceilings, and floors. Refer to Division 22 specifications.
- P. Install sleeve seals for piping penetrations of concrete walls and slabs. Refer to Division 22 specifications.

- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Refer to Division 22 specifications.

3.5 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. 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.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
- I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- J. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- K. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- L. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- M. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

- N. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- O. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.
- P. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
- Q. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.6 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

- A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and NFPA 13 for supports.

3.7 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Specialty Valves:
 - 1. Install valves in vertical position for proper direction of flow, in main supply to system.
 - 2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
 - 3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.8 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.
- B. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.9 FIRE-DEPARTMENT CONNECTION INSTALLATION

- A. Install wall-type fire-department connections.

- B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

3.10 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.11 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Coordinate with fire-alarm tests. Operate as required.
 - 6. Coordinate with fire-pump tests. Operate as required.
 - 7. Verify that equipment hose threads are same as local fire department equipment.
- B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.12 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.13 PIPING SCHEDULE

- A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight, black-steel pipe with cut or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

- D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4, shall be one of the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
- E. Standard-pressure, wet-pipe sprinkler system, NPS 5 and larger, shall be one of the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 3. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.

3.14 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended or Gyp Ceilings: Concealed sprinklers. Cover plate to match ceiling custom colors. Refer to the reflected ceiling plan.
 - 3. Wall Mounting: Sidewall sprinklers.
 - 4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as required.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - 2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
 - 3. Upright and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 21 13 13

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING 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 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.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
- B. 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 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. 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.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. 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.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 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. 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. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 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:

Malcolm X College – West Side Learning Center
Addition and Renovations

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: Prelubricated, 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.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING 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. Rubber union connector packless expansion joints.
 - 2. Flexible-hose packless expansion joints.
 - 3. Metal-bellows packless expansion joints.
 - 4. Grooved-joint expansion joints.
 - 5. Alignment guides and anchors.
 - 6. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Rubber Union Connector Expansion Joints :

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. General Rubber Corporation.
 - d. Mason Industries, Inc.
- 2. Material: Twin reinforced-rubber spheres with external restraining cables.
- 3. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C), unless otherwise indicated.
- 4. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

B. Flexible-Hose Packless Expansion Joints :

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Mason Industries, Inc.
 - d. Metraflex Company (The).
- 2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
- 3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
- 4. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.

- a. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. Hyspan Precision Products, Inc.
 - 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.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement 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: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install rubber packless expansion joints according to FSA-PSJ-703.
- C. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 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 mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four 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.

Malcolm X College – West Side Learning Center
Addition and Renovations

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

END OF SECTION 22016

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING 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. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.
 - 6. Silicone sealants.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, with plain ends and integral welded waterstop collar.
- C. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- D. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description:
1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 2. Designed to form a hydrostatic seal of **20 psig (137 kPa)** minimum.
 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 4. Pressure Plates: Stainless steel.
 5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

2.5 GROUT

- A. Description: Nonshrink, 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 (34.5-MPa)**, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

- A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, Use NT.
1. Sealant shall have a VOC content of 250 g/L or less.
 2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.
 - 1. Sealant shall have a VOC content of 250g/L or less.
 - 2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
 - 1. Sealant shall have a VOC content of 250 g/L or less.
 - 2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide **1-inch (25-mm)** 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 (50 mm)** above finished floor level.
 - 3. Using grout or silicone sealant, 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 (6.4-mm)** 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.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal

pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.
- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls 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.

3.4 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. Use grout or silicone sealant to seal the space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Cast-iron pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Cast-iron pipe sleeves.
 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Sleeve-seal fittings.
 - 1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping **NPS 6 (DN 150)** and Larger: Sleeve-seal fittings.
 - 1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.
 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping **NPS 6 (DN 150)** and Larger: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.
 4. Concrete Slabs above Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Steel pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Steel pipe sleeves.
 5. Interior Partitions:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Steel pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Galvanized-steel sheet sleeves.

Malcolm X College – West Side Learning Center
Addition and Renovations

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING 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. Escutcheons.
 - 2. Floor plates.

1.3 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

2.2 FLOOR PLATES

- A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 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 insulated piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping and Relocated Existing Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Chrome-Plated Piping: One-piece cast brass with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece cast brass with polished, chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece cast brass with rough-brass finish.
 - g. Bare Piping in Equipment Rooms: One-piece cast brass with rough-brass finish.
 - 2. Escutcheons for Existing Piping to Remain:
 - a. Chrome-Plated Piping: Split-casting, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
- 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 and Relocated Existing Piping: One-piece, floor plate.
 - 2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING 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. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.

- B. Related Requirements:

1. Section 221113 "Facility Water Distribution Piping" for domestic water meters and combined domestic and fire-protection water-service meters outside the building.
2. Section 221119 "Domestic Water Piping Specialties" for water meters.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

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

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 BIMETALLIC-ACTUATED THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ashcroft Inc.
 2. Marsh Bellofram.
 3. Miljoco Corporation.
 4. Palmer Wahl Instrumentation Group.
 5. Terice, H. O. Co.
 6. Weksler Glass Thermometer Corp.
- B. Standard: ASME B40.200.
- C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) nominal diameter.
- D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.
- E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- F. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
- G. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
- H. Window: Plastic.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

- A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Terice, H. O. Co.
 - e. Weiss Instruments, Inc.
 2. Standard: ASME B40.200.
 3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
 4. Element: Bourdon tube or other type of pressure element.

5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: Plastic.
9. Ring: Metal.
10. 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.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus or minus 1 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Trerice, H. O. Co.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch (152-mm) nominal size.
4. Case Form: Straight unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Weiss Instruments, Inc.
 - c. Weksler Glass Thermometer Corp.
2. Standard: ASME B40.200.
3. Case: Plastic; 6-inch (152-mm) nominal size.
4. Case Form: Straight unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: **3/4 inch (19 mm)**, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Palmer Wahl Instrumentation Group.
 - c. Trerice, H. O. Co.
 - d. Weiss Instruments, Inc.
 - e. Weksler Glass Thermometer Corp.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; **9-inch (229-mm)** nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Plastic.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: **1-1/4 inches (32 mm)**, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Marsh Bellofram.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Weiss Instruments, Inc.
 - e. Weksler Glass Thermometer Corp.
2. Standard: ASME B40.200.
3. Case: Plastic; **9-inch (229-mm)** nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: plastic.
8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 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.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1 (DN 15, DN 20, or NPS 25), ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), 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.

2.5 PRESSURE GAGES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Marsh Bellofram.
 - c. Miljoco Corporation.
 - d. Noshok.
 - e. Trerice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Weksler Glass Thermometer Corp.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

5. Pressure Connection: Brass, with **NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in **psi (kPa)**.
8. Pointer: Dark-colored metal.
9. Window: Plastic.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

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

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Marsh Bellofram.
 - c. Miljoco Corporation.
 - d. Trerice, H. O. Co.
 - e. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type; cast aluminum or drawn steel; **4-1/2-inch (114-mm)** nominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with **NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Plastic.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with **NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**, ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball, with **NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 1. Flow Design, Inc.
 2. Miljoco Corporation.
 3. Nexus Valve, Inc.
 4. Trerice, H. O. Co.
 5. Weiss Instruments, Inc.
 6. 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 (DN 8)** or **NPS 1/2 (DN 15)**, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: **500 psig at 200 deg F (3450 kPa at 93 deg C)**.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending a minimum of **2 inches (51 mm)** into fluid 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 direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install remote-mounted pressure gages on panel.
- I. Install valve and snubber in piping for each pressure gage for fluids.
- J. Install test plugs in piping tees.
- K. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlet and outlet of each domestic hot-water storage tank.
- L. Install pressure gages in the following locations:
 - 1. Building water service entrance into building.
 - 2. Inlet and outlet of each pressure-reducing valve.
 - 3. Suction and discharge of each domestic water pump.

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. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each domestic water heater shall be[**one of**] the following:
 - 1. Sealed, bimetallic-actuated type.
 - 2. Direct-mounted, metal-case, vapor-actuated type.
 - 3. Metal case, industrial-style, liquid-in-glass type.
- B. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be one of the following:
 - 1. Sealed, bimetallic-actuated type.
 - 2. Direct-mounted, metal-case, vapor-actuated type.
 - 3. Metal case, 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 Domestic Cold-Water Piping: 0 to 100 deg F and minus 20 to plus 50 deg C.
- B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F and 0 to 150 deg C.

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each water service into building shall be one of the following:
 - 1. Liquid-filled, direct-mounted, metal case.
- B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:
 - 1. Liquid-filled, direct-mounted, metal case.
- C. Pressure gages at suction and discharge of each domestic water pump shall be[**one of**] the following:
 - 1. Liquid-filled, direct-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 100 psi and 0 to 600 kPa.
- B. Scale Range for Domestic Water Piping: 0 to 200 psi and 0 to 1400 kPa.

END OF SECTION 220519

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Copper-alloy ball valves.
 - 2. Ferrous-alloy butterfly valves.
 - 3. Bronze check valves.
 - 4. Spring-loaded, lift-disc check valves.
 - 5. Gate valves.
- B. Related Sections include the following:
 - 1. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and charts.

1.2 DEFINITIONS

- A. The following are standard abbreviations for valves:
 - 1. CWP: Cold working pressure.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 3. NBR: Acrylonitrile-butadiene rubber.
 - 4. PTFE: Polytetrafluoroethylene plastic.
 - 5. TFE: Tetrafluoroethylene plastic.

1.3 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.4 QUALITY ASSURANCE

- A. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.
- B. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.
 3. Set gate valves closed.
 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 5. Set butterfly valves closed or slightly open.
 6. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 VALVES, GENERAL

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.
- C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
- F. Valve Actuators:
1. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
 2. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.
- G. Extended Valve Stems: On insulated valves.
- H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Grooved Ends: AWWA C606.

1. Solder Joint: With sockets according to ASME B16.18.

- a. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.

2. Threaded: With threads according to ASME B1.20.1.

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

2.3 COPPER-ALLOY BALL VALVES

A. Manufacturers:

1. Two-Piece, Copper-Alloy Ball Valves:

- a. Conbraco Industries, Inc.; Apollo Div.
- b. Milwaukee Valve Company.
- c. NIBCO, INC.
- d. Viega.
- e. Watts Industries, Inc.; Water Products Div.

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Bronze, lead free, dezincification resistant body with full-port, stainless steel ball; PTFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. Manufacturers:

1. Flange Style, Ferrous-Alloy Butterfly Valves:

- a. Milwaukee Valve Company.
- b. NIBCO, INC.
- c. Watts Industries, Inc.; Water Products Div.

B. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated.

C. Flanged, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Flanged-end type with one-piece stem.

2.5 BRONZE CHECK VALVES

A. Manufacturers:

1. Bronze, Swing Check Valves with Nonmetallic Disc:

- a. Apollo Valves.

- b. Hammond Valve.
- c. Milwaukee Valve Company.
- d. NIBCO, INC.
- e. Watts Industries, Inc.; Water Products Div.

- B. Bronze Check Valves, General: MSS SP-80.
- C. Type 4, Class 125, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.
- D. Type 4, Class 150, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.
- E. Type 4, Class 200, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

2.6 SPRING-LOADED, LIFT-DISC CHECK VALVES

- A. Manufacturers:
 - a. Grinnell Corporation.
 - b. Metraflex Co.
 - c. Milwaukee Valve Company.
 - d. NIBCO, INC.
- B. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.
- C. Type IV, Class 125, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends.
- D. Type IV, Class 150, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends.

2.7 GATE VALVES

- A. Gate Valves, Bronze, Class 150:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane.
 - b. Milwaukee Valve Company.
 - c. NIBCO, INC.
 - d. Apollo.
 - 2. Description:
 - a. Standard: MSS SP-80.
 - 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: Solid wedge; bronze.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable or ductile iron.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves in positions from fully open to fully close. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball or butterfly.
 - 2. Throttling Service: Ball, butterfly.
- B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.
- C. Domestic Water Piping: Use the following types of valves:
 - 1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
 - 2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
 - 3. Butterfly Valves, NPS 2-1/2 and Larger: Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
 - 4. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
 - 5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
 - 6. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.

7. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends.
8. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
9. For Copper Tubing, NPS 5 and Larger: Flanged ends.

3.3 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow and as follows:
 1. Swing Check Valves: In horizontal position with hinge pin level.
 2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Basic Division 22 Requirements" for basic piping joint construction.
- B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 ADJUSTING

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

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING 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. Pipe positioning systems.
8. 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 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
3. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

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 plumbing 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 and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. 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.

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, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Thomas & Betts Corporation; A Member of the ABB Group.
 - c. Unistrut; Part of Atkore International.
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 inturred 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.
7. Metallic Coating: Electroplated zinc.
8. Paint Coating: Epoxy or Alkyd.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Gripple 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 inturred 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.
7. Coating: Zinc.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ERICO International Corporation.
 2. National Pipe Hanger Corporation.
 3. Pipe Shields Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches (50 mm) 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, zinc-coated 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-Mounting-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 PIPE POSITIONING SYSTEMS

- A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.8 EQUIPMENT SUPPORTS

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

2.9 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: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

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. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.
- F. 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.
- G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. 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.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. 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 (DN 65) 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.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

- N. 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.
- O. 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 if insulation without vapor barrier is indicated. 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 (DN 100)** and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. 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 (DN 100)** 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 (DN 8 to DN 90): 12 inches (305 mm)** long and **0.048 inch (1.22 mm)** thick.
 - b. **NPS 4 (DN 100): 12 inches (305 mm)** long and **0.06 inch (1.52 mm)** thick.
 - c. **NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm)** long and **0.06 inch (1.52 mm)** thick.
 - d. **NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm)** long and **0.075 inch (1.91 mm)** thick.
 - e. **NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm)** long and **0.105 inch (2.67 mm)** thick.
 - 5. Pipes **NPS 8 (DN 200)** 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 inches (26 mm)**.

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 (0.05 mm)**.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 099113 "Exterior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

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 metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant 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** (**DN 15 to DN 750**).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to **1050 deg F** (**566 deg C**), pipes **NPS 4 to NPS 24** (**DN 100 to DN 600**), requiring up to **4 inches** (**100 mm**) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes **NPS 3/4 to NPS 36** (**DN 20 to DN 900**), requiring clamp flexibility and up to **4 inches** (**100 mm**) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes **NPS 1/2 to NPS 24** (**DN 15 to DN 600**) if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes **NPS 1/2 to NPS 4** (**DN 15 to DN 100**), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes **NPS 3/4 to NPS 8** (**DN 20 to DN 200**).
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes **NPS 1/2 to NPS 8** (**DN 15 to DN 200**).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes **NPS 1/2 to NPS 8** (**DN 15 to DN 200**).
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes **NPS 1/2 to NPS 8** (**DN 15 to DN 200**).
 - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes **NPS 3/8 to NPS 8** (**DN 10 to DN 200**).
 - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes **NPS 3/8 to NPS 3** (**DN 10 to DN 80**).
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes **NPS 1/2 to NPS 30** (**DN 15 to DN 750**).
 - 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 14. Pipe Saddle Supports (MSS Type 36): For support of pipes **NPS 4 to NPS 36** (**DN 100 to DN 900**), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes **NPS 4 to NPS 36** (**DN 100 to DN 900**), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes **NPS 2-1/2 to NPS 36** (**DN 65 to DN 900**) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes **NPS 1 to NPS 30 (DN 25 to DN 750)**, from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes **NPS 2-1/2 to NPS 24 (DN 65 to DN 600)**, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes **NPS 2 to NPS 42 (DN 50 to DN 1050)** if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes **NPS 2 to NPS 24 (DN 50 to DN 600)** if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes **NPS 2 to NPS 30 (DN 50 to DN 750)** 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 (DN 24 to DN 600)**.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers **NPS 3/4 to NPS 24 (DN 20 to DN 600)** 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 (150 mm)** for heavy loads.
 2. Steel Clevises (MSS Type 14): For **120 to 450 deg F (49 to 232 deg C)** 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 (49 to 232 deg C)** 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. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. 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 (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- 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 (32 mm).
 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.

- 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.
- S. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING 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. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Valve tags.
 - 5. Warning tags.

1.3 ACTION 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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Kolbi Pipe Marker Co.
 - c. Seton Identification Products.

2. Material and Thickness: Brass, 0.032-inch (0.8-mm) stainless steel, 0.025-inch (0.64-mm) aluminum, 0.032-inch (0.8-mm) or anodized aluminum, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black or Blue.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), 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.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Kolbi Pipe Marker Co.
 - c. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) <Insert dimension> thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black or Blue.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
7. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
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 (A4) 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.

2.2 WARNING SIGNS AND LABELS

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

1. Brady Corporation.
2. Brimar Industries, Inc.

3. [National Marker Company.](#)
 4. [Seton Identification Products.](#)
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/16 inch** thick, and having predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to **160 deg F.**
- F. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch.**
- G. 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.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
1. [Brady Corporation.](#)
 2. [Brimar Industries, Inc.](#)
 3. [Kolbi Pipe Marker Co.](#)
 4. [Seton Identification Products.](#)
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
1. 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.
 2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. Kolbi Pipe Marker Co.
 4. Seton Identification Products.
- B. 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**, **0.032-inch** minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link chain or beaded chain.
- C. 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.
1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. Kolbi Pipe Marker Co.
 4. Seton Identification Products.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
1. Size: Approximately **4 by 7 inches**.
 2. Fasteners: Reinforced grommet and wire or string.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Color: Safety 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 GENERAL INSTALLATION REQUIREMENTS

- 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.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Pipe Label Locations: Locate pipe labels where piping is exposed or 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 feet** 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: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- D. Pipe Label Color Schedule:
 - 1. Domestic Water Piping
 - a. Background: Safety green.
 - b. Letter Colors: White.
 - 2. Sanitary Waste and Storm Drainage Piping:
 - a. Background Color: Safety black.
 - b. Letter Color: White.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in 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. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - 2. Valve-Tag Colors:
 - a. Cold Water: Natural.
 - b. Hot Water: Natural.
 - 3. Letter Colors:
 - a. Cold Water: White.
 - b. Hot Water: White.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 220553

SECTION 22 07 19
PLUMBING PIPING INSULATION

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 insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mineral-Fiber Insulation
 - a. CertainTeed Manson
 - b. Knauf FiberGlass GmbH
 - c. Owens-Corning Fiberglas Corp.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

- E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- F. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Type I, 850° F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Fire Barrier Plenum Wrap:
 - 1. Inorganic fiber blanket with scrim-reinforced foil. Comply with ASTM E 84, NFPA 262 (UL910) and UL 1887, density of 6 pcf.

2.3 INSULATING CEMENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Brand
 - 2. Foster Brand
 - 3. Mon-Eco Industries
- B. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.4 ADHESIVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Brand
 - 2. Foster Brand
 - 3. Mon-Eco Industries
- B. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.5 MASTICS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Brand
 - 2. Foster Brand

3. Mon-Eco Industries

- B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- C. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180° F.
 - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 4. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180° F.
 - 3. Solids Content: 60 percent by volume and 66 percent by weight.
 - 4. Color: White.

2.6 SEALANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Brand
 - 2. Foster Brand
 - 3. Mon-Eco Industries
- B. FSK and Metal Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250° F.
 - 4. Color: Aluminum.
- C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250° F.
 - 4. Color: White.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Adhesive: As recommended by jacket material manufacturer.
 - 2. Color: White or Color as selected by Architect.
 - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 6.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

- A. Bands:
 - 1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
 - 2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.

2.11 PROTECTIVE SHIELDING GUARDS

- A. Manufacturers: Subject to compliance with requirements, provide by one of the following:
 - a. McGuire Manufacturing
 - b. Truebro
 - c. Zurn Industries
- B. Protective Shielding Pipe Covers:
 - 1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- C. Protective Shielding Piping Enclosures:
 - 1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300° F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.4 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 Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. 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 Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

3.5 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.
- 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 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.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 1. Drainage piping located in crawl spaces.
 2. Underground piping.
 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water: Operating temperature 35 to 60° F.
 - 1. Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - b. Field-Applied Fitting Covers: PVC
 - c. Vapor Barrier Required: Yes
- B. Domestic Hot and Recirculated Hot Water: Operating temperature 60 to 140° F or above.
 - 1. NPS 2 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - b. Field-Applied Fitting Covers: PVC
 - c. Vapor Barrier Required: No
- C. Stormwater and Overflow:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Insulation shall be the following:
- E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Field-Applied Jacket: PVC or molded vinyl P-trap and supply covers.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed:
 - 1. PVC: 20 mils thick.

END OF SECTION 22 07 19

SECTION 221113 - FACILITY WATER DISTRIBUTION 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. This Section includes water-distribution piping and related components outside the building for water service or combined water service and fire-service mains.
- B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.3 DEFINITIONS

- A. EPDM: Ethylene propylene diene terpolymer rubber.
- B. LLDPE: Linear, low-density polyethylene plastic.
- C. PA: Polyamide (nylon) plastic.
- D. PE: Polyethylene plastic.
- E. PP: Polypropylene plastic.
- F. PVC: Polyvinyl chloride plastic.
- G. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
- H. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - 1. Wiring Diagrams: Power, signal, and control wiring for alarms.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
 - 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
 - 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
- E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
- F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- G. NSF Compliance:
 - 1. Comply with NSF 14 for plastic potable-water-service piping.
 - 2. Comply with NSF 61 Annex G for materials for water-service piping and specialties for domestic water.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
 - 1. Ensure that valves are dry and internally protected against rust and corrosion.
 - 2. Protect valves against damage to threaded ends and flange faces.

3. Set valves in best position for handling. Set valves closed to prevent rattling.
- B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
- C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
- D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and specialties from moisture and dirt.
- G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.9 PROJECT CONDITIONS

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

1.10 COORDINATION

- A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: **ASTM B 88, Type K** (**ASTM B 88M, Type A**), water tube, annealed temper.
 1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
- B. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.

- C. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.2 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Gaskets: AWWA C111, rubber.
- C. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
 - 1. Grooved-End, Ductile-Iron Pipe Appurtenances:
 - a. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
 - b. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
- D. Flanges: ASME 16.1, Class 125, cast iron.

2.3 SPECIAL PIPE FITTINGS

- A. Ductile-Iron Rigid Expansion Joints:
 - 1. Description: Three-piece, ductile-iron assembly consisting of telescoping sleeve with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - a. Pressure Rating: 250 psig (1725 kPa) minimum.
 - b. Expansion Required: <Insert inches (mm)>.
- B. Ductile-Iron Flexible Expansion Joints:
 - 1. Description: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - a. Pressure Rating: 250 psig (1725 kPa) minimum.

- b. Offset: <Insert inches (mm)>.
- c. Expansion Required: <Insert inches (mm)>.

C. Ductile-Iron Deflection Fittings:

- 1. Description: Compound, ductile-iron coupling fitting with sleeve and 1 or 2 flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - a. Pressure Rating: 250 psig (1725 kPa) minimum.

2.4 JOINING MATERIALS

- A. Refer to Section 330500 "Common Work Results for Utilities" for commonly used joining materials.
- B. Brazing Filler Metals: AWS A5.8, BCuP Series.

2.5 PIPING SPECIALTIES

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. Tubular-Sleeve Pipe Couplings:
 - 1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
 - a. Standard: AWWA C219.
 - b. Center-Sleeve Material: Manufacturer's standard.
 - c. Gasket Material: Natural or synthetic rubber.
 - d. Pressure Rating: 150 psig (1035 kPa) minimum.
 - e. Metal Component Finish: Corrosion-resistant coating or material.
- C. Split-Sleeve Pipe Couplings:
 - 1. Description: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.
 - a. Standard: AWWA C219.
 - b. Sleeve Material: Manufacturer's standard.
 - c. Sleeve Dimensions: Of thickness and width required to provide pressure rating.
 - d. Gasket Material: O-rings made of EPDM rubber, unless otherwise indicated.
 - e. Pressure Rating: 150 psig (1035 kPa) minimum.
 - f. Metal Component Finish: Corrosion-resistant coating or material.
- D. Flexible Connectors:
 - 1. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
 - 2. Ferrous-Metal Piping: Stainless-steel hose covered with stainless-steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.

E. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Flanges:
 - a. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.
 - 3) Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
3. Dielectric-Flange Insulating Kits:
 - a. Description:
 - 1) Nonconducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel backing washers.
4. Dielectric Nipples:
 - a. Description:
 - 1) Standard: IAPMO PS 66
 - 2) Electroplated steel nipple complying with ASTM F 1545.
 - 3) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 4) End Connections: Male threaded or grooved.
 - 5) Lining: Inert and noncorrosive, propylene.

2.6 CORROSION-PROTECTION PIPING ENCASEMENT

A. Encasement for Underground Metal Piping:

1. Standards: ASTM A 674 or AWWA C105.
2. Form: Sheet or tube.
3. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness, or high-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.

2.7 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

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

- a. [Clow Valve Company; a subsidiary of McWane, Inc.](#)
 - b. [Crane; Crane Energy Flow Solutions.](#)
 - c. [Kennedy Valve Company; a division of McWane, Inc.](#)
 - d. [NIBCO INC.](#)
 - e. [U.S. Pipe and Foundry Company.](#)
 - f. [Zurn Industries, LLC.](#)
 2. Nonrising-Stem, Resilient-Seated Gate Valves:
 - a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - 1) Standard: AWWA C509.
 - 2) Minimum Pressure Rating: 200 psig (1380 kPa).
 - 3) End Connections: Mechanical joint.
 - 4) Interior Coating: Complying with AWWA C550.
 3. Nonrising-Stem, High-Pressure, Resilient-Seated Gate Valves:
 - a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - 1) Standard: AWWA C509.
 - 2) Minimum Pressure Rating: 250 psig (1725 kPa).
 - 3) End Connections: Push on or mechanical joint.
 - 4) Interior Coating: Complying with AWWA C550.
- B. UL/FMG, Cast-Iron Gate Valves:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. [Clow Valve Company; a subsidiary of McWane, Inc.](#)
 - b. [Crane; Crane Energy Flow Solutions.](#)
 - c. [Mueller Co.](#)
 - d. [Stockham; Crane Energy Flow Solutions.](#)
 - e. [U.S. Pipe and Foundry Company.](#)
 - f. [Zurn Industries, LLC.](#)
 2. UL/FMG, Nonrising-Stem Gate Valves:
 - a. Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.
 - 1) Standards: UL 262 and FMG approved.
 - 2) Minimum Pressure Rating: 175 psig (1207 kPa).
 - 3) End Connections: Flanged.
 3. OS&Y, Rising-Stem Gate Valves:
 - a. Description: Iron body and bonnet and bronze seating material.

- 1) Standards: UL 262 and FMG approved.
- 2) Minimum Pressure Rating: 175 psig (1207 kPa).
- 3) End Connections: Flanged.

C. Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane; Crane Energy Flow Solutions.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Stockham; Crane Energy Flow Solutions.
2. OS&Y, Rising-Stem Gate Valves:
 - a. Description: Bronze body and bonnet and bronze stem.
 - 1) Standards: UL 262 and FMG approved.
 - 2) Minimum Pressure Rating: 175 psig (1207 kPa).
 - 3) End Connections: Threaded.
3. Nonrising-Stem Gate Valves:
 - a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.
 - 1) Standard: MSS SP-80.

2.8 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Clow Valve Company; a subsidiary of McWane, Inc.
 - b. Flowserve Corporation.
 - c. Mueller Co.
 - d. U.S. Pipe and Foundry Company.
2. Description: Sleeve and valve compatible with drilling machine.
 - a. Standard: MSS SP-60.
 - b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
 - c. Valve: AWWA, cast-iron, nonrising-stem, resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

- B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately **5 inches (125 mm)** in diameter.
 - 1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.
- C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.9 CHECK VALVES

A. AWWA Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Clow Valve Company; a subsidiary of McWane, Inc.
 - b. Mueller Co.
 - c. NIBCO INC.
 - d. Stockham; Crane Energy Flow Solutions.
 - e. WATTS.
- 2. Description: Swing-check type with resilient seat. Include interior coating according to AWWA C550 and ends to match piping.
 - a. Standard: AWWA C508.
 - b. Pressure Rating: **175 psig (1207 kPa)**.

B. UL/FMG, Check Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Clow Valve Company; a subsidiary of McWane, Inc.
 - b. Globe Fire Sprinkler Corporation.
 - c. Reliable Automatic Sprinkler Co., Inc. (The).
 - d. Tyco Fire Products LP.
 - e. Victaulic Company.
 - f. Viking Corporation.
 - g. WATTS.
- 2. Description: Swing-check type with pressure rating; rubber-face checks, unless otherwise indicated; and ends matching piping.
 - a. Standards: UL 312 and FMG approved.
 - b. Pressure Rating: **175 psig (1207 kPa)**.

2.10 DETECTOR CHECK VALVES

A. Detector Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Badger Meter, Inc.
 - b. Globe Fire Sprinkler Corporation.
 - c. Mueller Co.
 - d. Victaulic Company.
 - e. Viking Corporation.
 - f. WATTS.
2. Description: Galvanized cast-iron body, bolted cover with air-bleed device for access to internal parts, and flanged ends. Include one-piece bronze disc with bronze bushings, pivot, and replaceable seat. Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.
 - a. Standards: UL 312 and FMG approved.
 - b. Pressure Rating: 175 psig (1207 kPa).
 - c. Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.

2.11 BUTTERFLY VALVES

A. AWWA Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. DeZURIK/Copes-Vulcan.
 - b. Milwaukee Valve Company.
 - c. Mosser Valve.
 - d. Mueller Co.
2. Description: Rubber seated.
 - a. Standard: AWWA C504.
 - b. Body: Cast or ductile iron.
 - c. Body Type: Flanged.
 - d. Pressure Rating: 150 psig (1035 kPa).

B. UL Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
2. Description: Metal on resilient material seating.
 - a. Standards: UL 1091 and FMG approved.
 - b. Body: Cast or ductile iron.
 - c. Body Type: Flanged.

- d. Pressure Rating: 175 psig (1207 kPa).

2.12 CORPORATION VALVES

A. Manufacturers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Ford Meter Box Company, Inc. (The).
 - c. Mueller Co.
 - d. Red Hed Manufacturing Company; a division of Everett J. Prescott, Inc.

B. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.

- 1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
- 2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
- 3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.

2.13 WATER METERS

A. Water meters will be furnished by utility company.

B. Manufacturers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Badger Meter, Inc.
 - b. Hays Fluid Controls.
 - c. Mueller Co.
 - d. Neptune Technology Group Inc.

C. Displacement-Type Water Meters:

- 1. Description: With bronze main case.
 - a. Standard: AWWA C700.
 - b. Registration: Flow in cubic feet (cubic meters).

D. Remote Registration System:

- 1. Description: Utility company standard; direct-reading type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - a. Standard: AWWA C706.
 - b. Registration: Flow in cubic feet (cubic meters).

E. Remote Registration System:

1. Description: Utility company standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - a. Standard: AWWA C707.
 - b. Registration: Flow in **cubic feet** (cubic meters).
 - c. Data-Acquisition Units: Comply with utility company requirements for type and quantity.
 - d. Visible Display Units: Comply with utility company requirements for type and quantity.

2.14 DETECTOR-TYPE WATER METERS

A. Detector-Type Water Meters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Badger Meter, Inc.
 - b. Mueller Co.
 - c. Neptune Technology Group Inc.

B. Description: Main line, proportional meter with second meter on bypass. Register flow in **cubic feet** (cubic meters).

1. Standards: AWWA C703, UL listed, and FMG approved.
2. Pressure Rating: **150 psig** (1035 kPa).
3. Bypass Meter: AWWA C702, compound-type, bronze case.
 - a. Size: At least one-half nominal size of main-line meter.

C. Description: Main-line turbine meter with strainer and second meter on bypass. Register flow in **cubic feet** (cubic meters).

1. Standards: AWWA C703, UL listed, and FMG approved.
2. Pressure Rating: **175 psig** (1207 kPa).
3. Bypass Meter: AWWA C701, turbine-type, bronze case.
 - a. Size: At least **NPS 2** (DN 50).

D. Remote Registration System:

1. Description: Utility company standard; direct-reading type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - a. Standard: AWWA C706.
 - b. Registration: Flow in **cubic feet** (cubic meters).

E. Remote Registration System:

1. Description: Utility company standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.

- a. Standard: AWWA C707.
- b. Registration: Flow in **cubic feet** (cubic meters).
- c. Data-Acquisition Units: Comply with utility company requirements for type and quantity.
- d. Visible Display Units: Comply with utility company requirements for type and quantity.

2.15 VACUUM BREAKERS

A. Pressure Vacuum Breaker Assembly:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FEBCO; A WATTS Brand.
 - b. Flowmatic Corporation.
 - c. WATTS.
 - d. Wilkins.
2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: **5 psig** (35 kPa) maximum, through middle 1/3 of flow range.
5. Size: **<Insert NPS (DN)>**.
6. Design Flow Rate: **<Insert gpm (L/s)>**.
7. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
8. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>**.
9. Accessories: Ball valves on inlet and outlet.

2.16 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Flowmatic Corporation.
 - c. WATTS.
 - d. Wilkins.
2. Standard: ASSE 1013 or AWWA C511.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: **12 psig** (83 kPa) maximum, through middle 1/3 of flow range.
5. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>** for **NPS 2 (DN 50)** and smaller; **<Insert psig (kPa)>** for **NPS 2-1/2 (DN 65)** and larger.
6. Body: Bronze for **NPS 2 (DN 50)** and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for **NPS 2-1/2 (DN 65)** and larger.
7. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2 (DN 65)** and larger.
8. Configuration: Designed for horizontal, straight through flow.
9. Accessories:

- a. Valves: Ball type with threaded ends on inlet and outlet of **NPS 2 (DN 50)** and smaller; OS&Y gate type with flanged ends on inlet and outlet of **NPS 2-1/2 (DN 65)** and larger.
- b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

B. Double-Check, Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Flowmatic Corporation.
 - c. WATTS.
 - d. Wilkins.
2. Standard: ASSE 1015 or AWWA C510.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: **5 psig (35 kPa)** maximum, through middle 1/3 of flow range.
5. Size: **<Insert NPS (DN)>**.
6. Design Flow Rate: **<Insert gpm (L/s)>**.
7. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
8. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>** for **NPS 2 (DN 50)** and smaller; **<Insert psig (kPa)>** for **NPS 2-1/2 (DN 65)** and larger.
9. Body: Bronze for **NPS 2 (DN 50)** and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for **NPS 2-1/2 (DN 65)** and larger.
10. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2 (DN 65)** and larger.
11. Configuration: Designed for horizontal, straight through flow.
12. Accessories: Ball valves with threaded ends on inlet and outlet of **NPS 2 (DN 50)** and smaller; OS&Y gate valves with flanged ends on inlet and outlet of **NPS 2-1/2 (DN 65)** and larger.

C. Reduced-Pressure-Detector, Fire-Protection Backflow Preventer Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; A WATTS Brand.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. WATTS.
 - d. Wilkins.
2. Standards: ASSE 1047 and UL listed or FMG approved.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: **12 psig (83 kPa)** maximum, through middle 1/3 of flow range.
5. Size: **<Insert NPS (DN)>**.
6. Design Flow Rate: **<Insert gpm (L/s)>**.
7. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
8. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>**.
9. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved.
10. End Connections: Flanged.
11. Configuration: Designed for horizontal, straight through flow.
12. Accessories:

- a. Valves: UL 262, FMG-approved, OS&Y gate type with flanged ends on inlet and outlet.
- b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.
- c. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

D. Double-Check, Detector-Assembly Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; A WATTS Brand.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. WATTS.
 - d. Wilkins.
2. Standards: ASSE 1048 and UL listed or FMG approved.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: **5 psig (35 kPa)** maximum, through middle 1/3 of flow range.
5. Size: **<Insert NPS (DN)>**.
6. Design Flow Rate: **<Insert gpm (L/s)>**.
7. Selected Unit Flow Range Limits: **<Insert gpm (L/s)>**.
8. Pressure Loss at Design Flow Rate: **<Insert psig (kPa)>**.
9. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved.
10. End Connections: Flanged.
11. Configuration: Designed for horizontal, straight through flow.
12. Accessories:
 - a. Valves: UL 262, FMG-approved, OS&Y gate type with flanged ends on inlet and outlet.
 - b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

2.17 WATER METER BOXES

- A. Description: Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" in top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.

2.18 CONCRETE VAULTS

- A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.
 1. Ladder: ASTM A 36/A 36M, steel or polyethylene-encased steel steps.
 2. Manhole: ASTM A 48/A 48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
 - a. Dimension: **24-inch (610-mm)** minimum diameter, unless otherwise indicated.
 3. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron traffic frame and cover.

- a. Dimension: ~~24-inch-~~ (610-mm-) minimum diameter, unless otherwise indicated.
4. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.19 PROTECTIVE ENCLOSURES

A. Freeze-Protection Enclosures:

1. Description: Insulated enclosure designed to protect aboveground water piping, equipment, or specialties from freezing and damage, with heat source to maintain minimum internal temperature of ~~40 deg F~~ (4 deg C) when external temperatures reach as low as ~~minus 34 deg F~~ (minus 36 deg C).
 - a. Standard: ASSE 1060.
 - b. Class I-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 - 1) Housing: Reinforced-aluminum or -fiberglass construction.
 - a) Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - b) Drain opening for units with drain connection.
 - c) Access doors with locking devices.
 - d) Insulation inside housing.
 - e) Anchoring devices for attaching housing to concrete base.
 - 2) Electric heating cable or heater with self-limiting temperature control.

B. Weather-Resistant Enclosures:

1. Description: Uninsulated enclosure designed to protect aboveground water piping, equipment, or specialties from weather and damage.
 - a. Standard: ASSE 1060.
 - b. Class III: For equipment or devices other than pressure or atmospheric vacuum breakers.
 - c. Class III-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.
 - 1) Housing: Reinforced-aluminum or -fiberglass construction.
 - a) Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
 - b) Drain opening for units with drain connection.
 - c) Access doors with locking devices.
 - d) Anchoring devices for attaching housing to concrete base.

C. Expanded-Metal Enclosures:

1. Description: Enclosure designed to protect aboveground water piping, equipment, or specialties from damage.

- a. Material: ASTM F 1267, expanded metal side and top panels, of weight and with reinforcement of same metal at edges as required for rigidity.
- b. Type: Type I, expanded.
- c. Class: Class 2, hot-dip, zinc-coated carbon steel.
- d. Finish: Manufacturer's enamel paint.
- e. Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
- f. Locking device.
- g. Lugs or devices for securing enclosure to base.

D. Enclosure Bases:

1. Description: **4-inch- (100-mm-)** minimum thickness precast concrete, of dimensions required to extend at least **6 inches (150 mm)** beyond edges of enclosure housings. Include openings for piping.

2.20 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Foundry Group, Inc.
 - b. EJ.
 - c. McWane, Inc.
 - d. Mueller Co.
 - e. U.S. Pipe and Foundry Company.
2. Description: Freestanding, with one **NPS 4-1/2 (DN 115)** and two **NPS 2-1/2 (DN 65)** outlets, **5-1/4-inch (133-mm)** main valve, drain valve, and **NPS 6 (DN 150)** mechanical-joint inlet. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
 - a. Standards: UL 246, FMG approved.
 - b. Pressure Rating: **150 psig (1035 kPa)** minimum.
 - c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - d. Operating and Cap Nuts: Pentagon, **1-1/2 inches (38 mm)** point to flat.
 - e. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
 - f. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.

B. Wet-Barrel Fire Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Clow Valve Company; a subsidiary of McWane, Inc.
 - b. McWane, Inc.
 - c. Mueller Co.

2. Description: Freestanding, with one **NPS 4-1/2 (DN 115)** and two **NPS 2-1/2 (DN 65)** outlets, **NPS 6 (DN 150)** threaded or flanged inlet, and base section with **NPS 6 (DN 150)** mechanical-joint inlet.
 - a. Standards: UL 246 and FMG approved.
 - b. Pressure Rating: **150 psig (1035 kPa)** minimum.
 - c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
 - d. Operating and Cap Nuts: Pentagon, **1-1/2 inches (38 mm)** point to flat.
 - e. Direction of Opening: Open hydrant valves by turning operating nut to left or counterclockwise.
 - f. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.

2.21 FLUSHING HYDRANTS

A. Post-Type Flushing Hydrants:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
 - a. Pressure Rating: **150 psig (1035 kPa)** minimum.
 - b. Outlet: One, with horizontal discharge.
 - c. Hose Thread: **NPS 2-1/2 (DN 65)**, with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
 - d. Barrel: Cast-iron or steel pipe with breakaway feature.
 - e. Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
 - f. Security: Locking device for padlock.
 - g. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.
 - h. Inlet: **NPS 2 (DN 50)** minimum.
 - i. Operating Wrench: One for each unit.

B. Ground-Type Flushing Hydrants:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
 - a. Pressure Rating: **150 psig (1035 kPa)** minimum.
 - b. Outlet: One, with **[vertical] [angle]** discharge.
 - c. Hose Thread: **NPS 2-1/2 (DN 65)**, with NFPA 1963 external hose thread for use by local fire department, and with cast-iron cap with brass chain.
 - d. Barrel: Cast-iron or steel pipe.
 - e. Valve: Bronze body with bronze-ball or plunger closure, and automatic draining.
 - f. Inlet: **NPS 2 (DN 50)** minimum.
 - g. Hydrant Box: Cast iron with cover, for ground mounting.
 - h. Operating Wrench: One for each unit.

C. Post-Type Sampling Station:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Nonfreeze and drainable, of length required for shutoff valve installation below frost line.
 - a. Pressure Rating: 100 psig (690 kPa) minimum.
 - b. Sampling Outlet: One unthreaded nozzle with handle.
 - c. Valve: Bronze body with bronze-ball or plunger closure. Include operating handle.
 - d. Drain: Tubing with separate manual vacuum pump.
 - e. Inlet: NPS 3/4 (DN 20) minimum.
 - f. Housing: Weatherproof material with locking device. Include anchor device.
 - g. Operating Wrench: One for each unit.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
- C. Do not use flanges or unions for underground piping.
- D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- E. Underground water-service piping NPS 3/4 to NPS 3 (DN 20 to DN 80) shall be any of the following:
 1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and brazed joints.
 2. NPS 1 to NPS 3 (DN 25 to DN 80) fiberglass, AWWA RTRP, Class 150; RTRF; and bonded joints.
 3. Fiberglass, AWWA RTRP, Class 150; RTRF; and bonded joints.
- F. Underground water-service piping NPS 4 to NPS 8 (DN 100 to DN 200) shall be any of the following:
 1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.
 2. PE, AWWA pipe; PE, AWWA fittings; and heat-fusion joints.
 3. NPS 4 and NPS 6 (DN 100 and DN 150): NPS 6 (DN 150) PVC, AWWA Class 150 pipe; PVC, AWWA Class 150 fabricated or molded fittings; and gasketed joints.
 4. NPS 8 (DN 200): PVC, AWWA Class 200 pipe; push-on-joint, ductile-iron fittings; and gasketed joints.
 5. Fiberglass, AWWA RTRP, Class 150; RTRF; and bonded joints.

- G. Water Meter Box Water-Service Piping **NPS 3/4 to NPS 2 (DN 20 to DN 50)** shall be same as underground water-service piping.
- H. Aboveground and Vault Water-Service Piping **NPS 3/4 to NPS 3 (DN 20 to DN 80)** shall be any of the following:
 - 1. Hard copper tube, **ASTM B 88, Type L (ASTM B 88M, Type B)**; wrought-copper, solder-joint fittings; and brazed or copper, pressure-seal fittings; and pressure-sealed joints.
- I. Aboveground and vault water-service piping **NPS 4 to NPS 8 (DN 100 to DN 200)** shall be any of the following:
 - 1. Hard copper tube, **ASTM B 88, Type L (ASTM B 88M, Type B)**; wrought-copper, solder-joint fittings; and brazed joints.
 - 2. Ductile-iron, grooved-end pipe; ductile-iron, grooved-end appurtenances; and grooved joints.
- J. Underground Fire-Service-Main Piping **NPS 4 to NPS 12 (DN 100 to DN 300)** shall be any of the following:
 - 1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.
- K. Aboveground and Vault Fire-Service-Main Piping **NPS 4 to NPS 12 (DN 100 to DN 300)** shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.
- L. Underground Combined Water-Service and Fire-Service-Main Piping **NPS 6 to NPS 12 (DN 150 to DN 300)** shall be any of the following:
 - 1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.
- M. Aboveground and Vault Combined Water Service and Fire-Service-Main Piping **NPS 6 to NPS 12 (DN 150 to DN 300)** shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

3.3 VALVE APPLICATIONS

- A. General Application: Use mechanical-joint-end valves for **NPS 3 (DN 80)** and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for **NPS 2 (DN 50)** and smaller installation.
- B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Underground Valves, **NPS 3 (DN 80)** and Larger: AWWA, cast-iron, nonrising-stem, high-pressure, resilient-seated gate valves with valve box.
 - 2. Underground Valves, **NPS 4 (DN 100)** and Larger, for Indicator Posts: UL/FMG, cast-iron, nonrising-stem gate valves with indicator post.
 - 3. Use the following for valves in vaults and aboveground:
 - a. Gate Valves, **NPS 2 (DN 50)** and Smaller: Bronze, nonrising stem.
 - b. Gate Valves, **NPS 3 (DN 80)** and Larger: UL/FMG, cast iron, OS&Y rising stem.

- c. Check Valves: UL/FMG, swing type.
- 4. Pressure-Reducing Valves: Use for water-service piping in vaults and aboveground to control water pressure.
- 5. Relief Valves: Use for water-service piping in vaults and aboveground.
 - a. Air-Release Valves: To release accumulated air.
 - b. Air/Vacuum Valves: To release or admit large volume of air during filling of piping.
 - c. Combination Air Valves: To release or admit air.
- 6. Detector Check Valves: Use for water-service piping in vaults and aboveground to detect unauthorized use of water.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. See Section 330500 "Common Work Results for Utilities" for piping-system common requirements.

3.5 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.
- B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- C. Make connections larger than **NPS 2 (DN 50)** with tapping machine according to the following:
 - 1. Install tapping sleeve and tapping valve according to MSS SP-60.
 - 2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
 - 3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
 - 4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
- D. Make connections **NPS 2 (DN 50)** and smaller with drilling machine according to the following:
 - 1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
 - 2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
 - 3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
 - 4. Install corporation valves into service-saddle assemblies.
 - 5. Install manifold for multiple taps in water main.
 - 6. Install curb valve in water-service piping with head pointing up and with service box.
- E. Comply with NFPA 24 for fire-service-main piping materials and installation.

1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
 2. Install copper tube and fittings according to CDA's "Copper Tube Handbook."
- F. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
- G. Install PE pipe according to ASTM D 2774 and ASTM F 645.
- H. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.
- I. Install fiberglass AWWA pipe according to AWWA M45.
- J. Bury piping with depth of cover over top at least **30 inches (750 mm)**, with top at least **12 inches (300 mm)** below level of maximum frost penetration, and according to the following:
1. Under Driveways: With at least **36 inches (910 mm)** cover over top.
 2. Under Railroad Tracks: With at least **48 inches (1220 mm)** cover over top.
 3. In Loose Gravelly Soil and Rock: With at least **12 inches (300 mm)** additional cover.
- K. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- L. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
- M. Sleeves are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- N. Mechanical sleeve seals are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- O. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
- P. See Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for fire-suppression-water piping inside the building.
- Q. See Section 221116 "Domestic Water Piping" for potable-water piping inside the building.

3.6 JOINT CONSTRUCTION

- A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.
- B. Make pipe joints according to the following:
1. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.

2. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
3. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
4. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
5. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
6. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
7. Fiberglass Piping Bonded Joints: Use adhesive and procedure recommended by piping manufacturer.
8. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - a. Dielectric Fittings for **NPS 2 (DN 50)** and Smaller: Use dielectric nipples.
 - b. Dielectric Fittings for **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Use dielectric flange kits or nipples.
 - c. Dielectric Fittings for **NPS 5 (DN 125)** and Larger: Use dielectric flange kits.

3.7 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
 1. Concrete thrust blocks.
 2. Locking mechanical joints.
 3. Set-screw mechanical retainer glands.
 4. Bolted flanged joints.
 5. Heat-fused joints.
 6. Pipe clamps and tie rods.
 7. .
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
 1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
 2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
 3. Bonded-Joint Fiberglass, Water-Service Piping: According to AWWA M45.
 4. Fire-Service-Main Piping: According to NFPA 24.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
- C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.
- D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.
- E. MSS Valves: Install as component of connected piping system.
- F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.
- G. Pressure-Reducing Valves: Install in vault or aboveground between shutoff valves. Install full-size valved bypass.
- H. Relief Valves: Comply with AWWA C512. Install aboveground with shutoff valve on inlet.

3.9 DETECTOR-CHECK VALVE INSTALLATION

- A. Install in vault or aboveground.
- B. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.
- C. Support detector check valves, meters, shutoff valves, and piping on brick or concrete piers.

3.10 WATER METER INSTALLATION

- A. Install water meters, piping, and specialties according to utility company's written instructions.
- B. Water Meters: Install displacement-type water meters, **NPS 2 (DN 50)** and smaller, in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets and valved bypass around meters unless prohibited by authorities having jurisdiction.
- C. Water Meters: Install compound-type water meters, **NPS 3 (DN 80)** and larger, in meter vaults. Include shutoff valves on water meter inlets and outlets and valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.
- D. Water Meters: Install detector-type water meters in meter vault according to AWWA M6. Include shutoff valves on water meter inlets and outlets and full-size valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.

3.11 ROUGHING-IN FOR WATER METERS

- A. Rough-in piping and specialties for water meter installation according to utility company's written instructions.

3.12 VACUUM BREAKER ASSEMBLY INSTALLATION

- A. Install pressure vacuum breaker assemblies of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install pressure vacuum breaker assemblies in vault or other space subject to flooding.

3.13 BACKFLOW PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.
- C. Do not install bypass piping around backflow preventers.
- D. Support **NPS 2-1/2 (DN 65)** and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.14 WATER METER BOX INSTALLATION

- A. Install water meter boxes in paved areas flush with surface.
- B. Install water meter boxes in grass or earth areas with top **2 inches (50 mm)** above surface.

3.15 CONCRETE VAULT INSTALLATION

- A. Install precast concrete vaults according to ASTM C 891.

3.16 PROTECTIVE ENCLOSURE INSTALLATION

- A. Install concrete base level and with top approximately **2 inches (50 mm)** above grade.
- B. Install protective enclosure over valves and equipment.
- C. Anchor protective enclosure to concrete base.

3.17 FIRE HYDRANT INSTALLATION

- A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.
- B. Wet-Barrel Fire Hydrants: Install with valve below frost line. Provide for drainage.
- C. AWWA Fire Hydrants: Comply with AWWA M17.

- D. UL/FMG Fire Hydrants: Comply with NFPA 24.

3.18 FLUSHING HYDRANT INSTALLATION

- A. Install post-type flushing hydrants with valve below frost line and provide for drainage. Support in upright position. Include separate gate valve or curb valve and restrained joints in supply piping.
- B. Install ground-type flushing hydrants with valve below frost line and provide for drainage. Install hydrant box flush with grade. Include separate gate valve or curb valve and restrained joints in supply piping.
- C. Install sampling stations with valve below frost line and provide for drainage. Attach weather-resistant housing and support in upright position. Include separate curb valve in supply piping.

3.19 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install ball drip valves at each check valve for fire department connection to mains.
- B. Install protective pipe bollards on three sides of each fire department connection. Pipe bollards are specified in Section 055000 "Metal Fabrications."

3.20 ALARM DEVICE INSTALLATION

- A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.
- B. Supervisory Switches: Supervise valves in open position.
 - 1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
 - 2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.
- C. Locking and Sealing: Secure unsupervised valves as follows:
 - 1. Valves: Install chain and padlock on open OS&Y gate valve.
 - 2. Post Indicators: Install padlock on wrench on indicator post.
- D. Pressure Switches: Drill and thread hole in exposed barrel of fire hydrant. Install switch.
- E. Water-Flow Indicators: Install in water-service piping in vault. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.
- F. Connect alarm devices to building fire alarm system. Wiring and fire-alarm devices are specified in Section 284621.11 "Addressable Fire-Alarm Systems" and Section 284621.13 "Conventional Fire-Alarm Systems."

3.21 CONNECTIONS

- A. See Section 330500 "Common Work Results for Utilities" for piping connections to valves and equipment.
- B. Connect water-distribution piping to [utility water main] [existing water main] <Insert piping system>. Use [tapping sleeve and tapping valve] [service clamp and corporation valve] <Insert method>.
- C. Connect water-distribution piping to interior domestic water and fire-suppression piping.
- D. Connect waste piping from concrete vault drains to sanitary sewerage system. See Section 221313 "Facility Sanitary Sewers" for connection to sanitary-sewer piping.
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.22 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
 - 1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- C. Prepare reports of testing activities.

3.23 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."
- B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Section 330500 "Common Work Results for Utilities" for identifying devices.

3.24 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 - 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing

- of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 4. follows:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
 - c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

- B. Prepare reports of purging and disinfecting activities.

END OF SECTION 221113

SECTION 221116 - DOMESTIC WATER 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. Copper tube and fittings.
 - 2. Piping joining materials.
 - 3. Transition fittings.
 - 4. Dielectric fittings.
- B. Related Requirements:
 - 1. Section 221113 "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.3 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

- A. System purging and disinfecting activities report.
- B. Field quality-control reports.

1.5 FIELD CONDITIONS

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G.
- C. Comply with NSF 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: **ASTM B 88, Type L** water tube, drawn temper.
- B. Soft Copper Tube: **ASTM B 88, Type K** water tube, annealed temper.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- E. Copper Unions:
 - 1. MSS SP-123.
 - 2. Cast-copper-alloy, hexagonal-stock body.
 - 3. Ball-and-socket, metal-to-metal seating surfaces.
 - 4. Solder-joint or threaded ends.

2.3 TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Sleeve-Type Transition Coupling: AWWA C219.

2.4 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Nipples:
 - 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:

- a. Grinnell Mechanical Products.
 - b. Matco-Norca.
 - c. Victaulic Company.
2. Standard: IAPMO PS 66.
 3. Electroplated steel nipple complying with ASTM F 1545.
 4. Pressure Rating and Temperature: 300 psig at 225 deg F.
 5. End Connections: Male threaded or grooved.
 6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. All copper piping below floor shall be installed in a sleeve. No joints will be allowed below floor.
- D. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- E. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
- F. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."
- G. Install shutoff valve immediately upstream of each dielectric fitting.
- H. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."
- I. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- J. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- K. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

- L. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- M. 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.
- N. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- O. Install piping to permit valve servicing.
- P. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- Q. Install piping free of sags and bends.
- R. Install fittings for changes in direction and branch connections.
- S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- T. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."
- U. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."
- V. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- D. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

- E. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
- F. g bolts.

3.4 TRANSITION FITTING INSTALLATION

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for **NPS 1-1/2** and Smaller: Fitting-type coupling.
 - 2. Fittings for **NPS 2** and Larger: Sleeve-type coupling.
- C. Transition Fittings in Aboveground Domestic Water Piping **NPS 2** and Smaller: Plastic-to-metal transition fittings.

3.5 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for **NPS 2** and Smaller: Use dielectric nipples.
- C. Dielectric Fittings for **NPS 2-1/2 to NPS 4**: Use dielectric flange kits or nipples.
- D. Dielectric Fittings for **NPS 5** and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. **100 Feet** and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than **100 Feet**: MSS Type 43, adjustable roller hangers.
 - c. Longer Than **100 Feet** if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs **100 Feet** or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of **3/8 inch**.

- D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 - 6. NPS 6: 10 feet with 5/8-inch rod.
- E. Install supports for vertical copper tubing every 10 feet.
- F. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - 1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
 - 2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - 3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 - 4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Piping Inspections:

- a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
- b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
- c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
- d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

- a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
- b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
- c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
- d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
- e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
- f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be one of the following:
 1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
- E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:

1. Soft copper tube, **ASTM B 88, Type K**; wrought-copper, solder-joint fittings; and brazed joints.
- F. Under-building-slab, domestic water piping, **NPS 2 (DN 50)** and smaller, shall be one of the following:
 1. Soft copper tube, **ASTM B 88, Type K (ASTM B 88M, Type B)**; wrought-copper, solder-joint fittings; and brazed joints.
- G. Aboveground domestic water piping, **NPS 2 (DN 50)** and smaller, shall be one of the following:
 1. Hard copper tube, **ASTM B 88, Type L (ASTM B 88M, Type B)**; cast- or wrought-copper, solder-joint fittings; and soldered joints.
- H. Aboveground domestic water piping, **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**, shall be one of the following:
 1. Hard copper tube, **ASTM B 88, Type L (ASTM B 88M, Type B)**; cast- or wrought-copper, solder-joint fittings; and soldered joints.
- I. Aboveground domestic water piping, **NPS 5 to NPS 8 (DN 125 to DN 200)**, shall be one of the following:
 1. Hard copper tube, **ASTM B 88, Type L (ASTM B 88M, Type B)**; cast- or wrought-copper, solder-joint fittings; and soldered joints.
 2. Hard copper tube, **ASTM B 88, Type L (ASTM B 88M, Type B)**; grooved-joint, copper-tube appurtenances; and grooved joints.

3.13 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 1. Shutoff Duty: Use ball valves for piping **NPS 2 (DN 50)** and smaller. Use butterfly, or ball valves with flanged ends for piping **NPS 2-1/2 (DN 65)** and larger.
 2. Throttling Duty: Use ball or globe valves for piping **NPS 2 (DN 50)** and smaller. Use ball valves with flanged ends for piping **NPS 2-1/2 (DN 65)** and larger.
 3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER 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:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers.
7. Outlet boxes.
8. Hose stations.
9. Hose bibbs.
10. Wall hydrants.
11. Ground hydrants.
12. Post hydrants.
13. Drain valves.
14. Water-hammer arresters.
15. Air vents.
16. Trap-seal primer valves.
17. Trap-seal primer systems.
18. Specialty valves.
19. Flexible connectors.
20. Water meters.

- B. Related Requirements:

1. Section 220519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 221116 "Domestic Water Piping" for water meters.
3. Section 223200 "Domestic Water Filtration Equipment" for water filters in domestic water piping.
4. Section 224713 "Drinking Fountains" for water filters for water coolers.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: For domestic water piping specialties.
 - 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 Annex G..

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: **125 psig (860 kPa)** unless otherwise indicated.

2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; A WATTS Brand.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. WATTS.
 - d. Zurn Industries, LLC.
 - 2. Standard: ASSE 1001.
 - 3. Size: **NPS 1/4 to NPS 3 (DN 8 to DN 80)**, as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Chrome plated.
- B. Hose-Connection Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.

- b. [MIFAB, Inc.](#)
 - c. [WATTS.](#)
 - d. [Zurn Industries, LLC.](#)
 2. Standard: ASSE 1011.
 3. Body: Bronze, nonremovable, with manual drain.
 4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
 5. Finish: Chrome or nickel plated.
- C. Pressure Vacuum Breakers:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. [Ames Fire & Waterworks; A WATTS Brand.](#)
 - b. [Apollo Flow Controls; Conbraco Industries, Inc.](#)
 - c. [Flomatic Corporation.](#)
 - d. WATTS.
 2. Standard: ASSE 1020.
 3. Operation: Continuous-pressure applications.
 4. Pressure Loss: 5 psig (35 kPa) maximum, through middle third of flow range.
 5. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

- A. Intermediate Atmospheric-Vent Backflow Preventers:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. [Apollo Flow Controls; Conbraco Industries, Inc.](#)
 - b. [WATTS.](#)
 - c. [Zurn Industries, LLC.](#)
 2. Standard: ASSE 1012.
 3. Operation: Continuous-pressure applications.
 4. Body: Bronze.
 5. End Connections: Solder joint.
 6. Finish: Chrome plated.
- B. Reduced-Pressure-Principle Backflow Preventers:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. [Ames Fire & Waterworks; A WATTS Brand.](#)
 - b. [Apollo Flow Controls; Conbraco Industries, Inc.](#)
 - c. [Flomatic Corporation.](#)
 - d. WATTS.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig (83 kPa) maximum, through middle third of flow range.
5. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
6. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
7. Configuration: Designed for horizontal, straight-through flow.
8. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Double-Check, Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; A WATTS Brand.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. Flomatic Corporation.
 - d. WATTS.
2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications unless otherwise indicated.
4. Pressure Loss: 5 psig (35 kPa) maximum, through middle third of flow range.
5. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
6. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
7. Configuration: Designed for horizontal, straight-through flow.
8. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

D. Beverage-Dispensing-Equipment Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. WATTS.
2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8 (DN 8 or DN 10).
5. Body: Stainless steel.
6. End Connections: Threaded.

E. Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Flomatic Corporation.
 - c. Mueller Co.
 - d. WATTS.
2. Standard: ASSE 1024.
3. Operation: Continuous-pressure applications.
4. Body: Bronze with union inlet.

F. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cash Acme, A Division of Reliance Worldwide Corporation.
 - b. Lancer Corporation.
 - c. WATTS.
2. Standard: ASSE 1032.
3. Operation: Continuous-pressure applications.
4. Size: **NPS 1/4 or NPS 3/8 (DN 8 or DN 10).**
5. Body: Stainless steel.
6. End Connections: Threaded.

G. Hose-Connection Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. WATTS.
 - c. Woodford Manufacturing Company.
2. Standard: ASSE 1052.
3. Operation: Up to **10-foot head of water (30-kPa)** back pressure.
4. Inlet Size: **NPS 1/2 or NPS 3/4 (DN 15 or DN 20).**
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least **3-gpm (0.19-L/s)** flow.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Cash Acme, A Division of Reliance Worldwide Corporation.
 - c. WATTS.

- d. [Zurn Industries, LLC.](#)
 2. Standard: ASSE 1003.
 3. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
 4. Body: Bronze with chrome-plated finish for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
 5. Valves for Booster Heater Water Supply: Include integral bypass.
 6. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
- B. Water-Control Valves:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. [Apollo Flow Controls; Conbraco Industries, Inc.](#)
 - b. [CLA-VAL Automatic Control Valves.](#)
 - c. [Flomatic Corporation.](#)
 - d. [WATTS.](#)
 2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
 3. Pressure Rating: Initial working pressure of 150 psig (1035 kPa) minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
 4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
 - a. Trim: Stainless steel.
 5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.

2.6 BALANCING VALVES

- A. Copper-Alloy Calibrated Balancing Valves:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. [Armstrong International, Inc.](#)
 - b. [ITT Corporation.](#)
 - c. [NIBCO INC.](#)
 - d. [TACO Comfort Solutions, Inc.](#)
 - e. [WATTS.](#)
 2. Type: Ball or Y-pattern globe valve with two readout ports and memory-setting indicator.
 3. Body: Brass or bronze.
 4. Size: Same as connected piping, but not larger than NPS 2 (DN 50).
 5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
- B. Cast-Iron Calibrated Balancing Valves:
1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

- a. [Armstrong International, Inc.](#)
 - b. [ITT Corporation.](#)
2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
3. Size: Same as connected piping, but not smaller than **NPS 2-1/2 (DN 65)**.
- C. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
- D. Memory-Stop Balancing Valves:
 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. [Apollo Flow Controls; Conbraco Industries, Inc.](#)
 - b. [Milwaukee Valve Company.](#)
 - c. [NIBCO INC.](#)
 - d. [Stockham; Crane Energy Flow Solutions.](#)
 2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
 3. Pressure Rating: **400-psig (2760-kPa)** minimum CWP.
 4. Size: **NPS 2 (DN 50)** or smaller.
 5. Body: Copper alloy.
 6. Port: Standard or full port.
 7. Ball: Chrome-plated brass.
 8. Seats and Seals: Replaceable.
 9. End Connections: Solder joint or threaded.
 10. Handle: Vinyl-covered steel with memory-setting device.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

- A. Water-Temperature Limiting Devices:
 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. [Apollo Flow Controls; Conbraco Industries, Inc.](#)
 - b. [Honeywell.](#)
 - c. [Leonard Valve Company.](#)
 - d. [POWERS; A WATTS Brand.](#)
 - e. [Symmons Industries, Inc.](#)
 - f. **WATTS.**
 - g. [Zurn Industries, LLC.](#)
 2. Standard: ASSE 1017.
 3. Pressure Rating: **125 psig (860 kPa)**.
 4. Type: Thermostatically controlled, water mixing valve.
 5. Material: Bronze body with corrosion-resistant interior components.
 6. Connections: Threaded union inlets and outlet.
 7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
 8. Tempered-Water Setting: **110 deg F.**
 9. Tempered-Water Design Flow Rate: **<Insert gpm (L/s)>.**

10. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. POWERS; A WATTS Brand.
 - c. Symmons Industries, Inc.
 - d. Zurn Industries, LLC.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
4. Type: Cabinet-type, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F.
9. Selected Valve Flow Rate at 45-psig (310-kPa) Pressure Drop: <Insert gpm (L/s)>.
10. Pressure Drop at Design Flow Rate: <Insert psig (kPa)>.
11. Valve Finish: Rough bronze.
12. Piping Finish: Copper.
13. Cabinet: Factory fabricated, stainless steel, for surface mounting and with hinged, stainless-steel door.

C. Manifold, Thermostatic, Water Mixing-Valve Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Leonard Valve Company.
 - b. POWERS; A WATTS Brand.
 - c. Symmons Industries, Inc.
2. Description: Factory-fabricated, exposed-mounted, thermostatically controlled, water mixing-valve assembly in two-valve parallel arrangement.
3. Large-Flow Parallel: Thermostatic, water mixing valve and downstream-pressure regulator with pressure gages on inlet and outlet.
4. Intermediate-Flow Parallel: Thermostatic, water mixing valve and downstream-pressure regulator with pressure gages on inlet and outlet.
5. Small-Flow Parallel: Thermostatic, water mixing valve.
6. Thermostatic Mixing Valves: Comply with ASSE 1017. Include check stops on hot- and cold-water inlets and shutoff valve on outlet.
7. Water Regulator(s): Comply with ASSE 1003. Include pressure gage on inlet and outlet.
8. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
9. Thermostatic Mixing Valve and Water Regulator Finish: Rough bronze.
10. Piping Finish: Copper.

D. Individual-Fixture, Water Tempering Valves:

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

- a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Leonard Valve Company.
 - c. POWERS; A WATTS Brand.
 - d. WATTS.
 - e. Zurn Industries, LLC.
2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
 3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
 4. Body: Bronze body with corrosion-resistant interior components.
 5. Temperature Control: Adjustable.
 6. Inlets and Outlet: Threaded.
 7. Finish: Rough or chrome-plated bronze.

E. Primary Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Heat-Timer Corporation.
 - b. Holby Valve Inc.
 - c. Uponor.
2. Standard: ASSE 1017, thermostatically controlled, water tempering valve, listed as tempering valve.
3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
4. Body: Bronze.
5. Temperature Control: Manual.
6. Inlets and Outlet: Threaded.
7. Valve Finish: Rough bronze.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 (DN 50) and Smaller: 0.020 inch (0.51 mm).
 - b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.045 inch (1.14 mm).
 - c. Strainers NPS 5 (DN 125) and Larger: 0.125 inch (3.18 mm).
6. Drain: Factory-installed, hose-end drain valve.

2.9 OUTLET BOXES

A. Clothes Washer Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. IPS Corporation.
 - b. Oatey.
 - c. Symmons Industries, Inc.
 - d. WATTS.
 - e. Zurn Industries, LLC.
2. Mounting: Recessed.
3. Material and Finish: Plastic box and faceplate.
4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Supply Shutoff Fittings: **NPS 1/2 (DN 15)** gate, globe, or ball valves and **NPS 1/2 (DN 15)** copper, water tubing.
6. Drain: **NPS 2 (DN 50)** standpipe and P-trap for direct waste connection to drainage piping.
7. Inlet Hoses: Two **60-inch- (1500-mm-)** long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
8. Drain Hose: One **48-inch- (1200-mm-)** long, rubber household clothes washer drain hose with hooked end.

B. Ice maker Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. IPS Corporation.
 - b. Oatey.
2. Mounting: Recessed.
3. Material and Finish: Stainless-steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include **NPS 1/2 (DN 15)** or smaller copper tube outlet.
5. Supply Shutoff Fitting: **NPS 1/2 (DN 15)** gate, globe, or ball valve and **NPS 1/2 (DN 15)** copper, water tubing.

2.10 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: **NPS 1/2 or NPS 3/4 (DN 15 or DN 20)** threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: **125 psig (860 kPa).**
7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.

8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.11 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. MIFAB, Inc.
 - c. WATTS.
 - d. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys(s): One with each wall hydrant.

B. Nonfreeze, Hot- and Cold-Water Wall Hydrants <Insert drawing designation if any>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. WATTS.
 - c. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.
5. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.

10. Vacuum Breaker:
 - a. Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
 - b. Garden-hose thread complying with ASME B1.20.7 on outlet.
11. Operating Key(s): One with each wall hydrant.

2.12 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves.
2. Pressure Rating: 200-psig (1380-kPa) minimum CWP or Class 125.
3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 (DN 6) side outlet with cap.

2.13 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Jay R. Smith Mfg. Co.
 - c. Josam Company.
 - d. MIFAB, Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Tyler Pipe; a subsidiary of McWane Inc.
 - g. WATTS.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.14 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating and Temperature: 125-psig (860-kPa) minimum pressure rating at 140 deg F (60 deg C).
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 (DN 15) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig (1035-kPa) minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 (DN 10) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.15 FLEXIBLE CONNECTORS

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

1. Flexicraft Industries.
2. Hyspan Precision Products, Inc.
3. Metraflex Company (The).

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
2. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.16 WATER METERS

A. Displacement-Type Water Meters:

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

- b. [Carlson Meter.](#)
- c. [Mueller Co.](#)
- d. [Schlumberger Limited.](#)
- e. [Sensus.](#)

2. Description:

- a. Standard: AWWA C700.
- b. Pressure Rating: 150-psig (1035-kPa) working pressure.
- c. Body Design: Nutating disc; totalization meter.
- d. Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
- e. Case: Bronze.
- f. End Connections: Threaded.

B. Turbine-Type Water Meters:

1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

- a. [ABB.](#)
- b. [Badger Industries, Inc.](#)
- c. [Hays Fluid Controls.](#)
- d. [Mueller Co.](#)
- e. [Schlumberger Limited.](#)
- f. [Sensus.](#)

2. Description:

- a. Standard: AWWA C701.
- b. Pressure Rating: 150-psig (1035-kPa) working pressure.
- c. Body Design: Turbine; totalization meter.
- d. Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
- e. Case: Bronze.
- f. End Connections for Meters NPS 2 (DN 50) and Smaller: Threaded.
- g. End Connections for Meters NPS 2-1/2 (DN 65) and Larger: Flanged.

C. Compound-Type Water Meters:

1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

- a. [ABB.](#)
- b. [Badger Industries, Inc.](#)
- c. [Mueller Co.](#)
- d. [Schlumberger Limited.](#)
- e. [Sensus.](#)

2. Description:

- a. Standard: AWWA C702.
- b. Pressure Rating: 150-psig (1035-kPa) working pressure.
- c. Body Design: With integral mainline and bypass meters; totalization meter.
- d. Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.

- e. Case: Bronze.
 - f. Pipe Connections: Flanged.
- D. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.
- E. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
- 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- C. Install water-control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.
- D. Install balancing valves in locations where they can easily be adjusted.
- E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
- 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- F. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve and pump.
- G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."
- H. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
- 1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

I. Refrigerated Case Requirements:

1. Install a minimum of one quick-connect hose connection (QCHC) for each misting produce case.
2. Install a keyed shutoff valve installed immediately over each run of refrigerated cases with at least one valve per 50 lineal feet.

J. Install ground hydrants with 1 cu. yd. (0.75 cu. m) of crushed gravel around drain hole. Set ground hydrants with box flush with grade.

K. Install draining-type post hydrants with 1 cu. yd. (0.75 cu. m) of crushed gravel around drain hole. Set post hydrants in concrete paving or in 1 cu. ft. (0.03 cu. m) of concrete block at grade.

L. Set nonfreeze, nondraining-type post hydrants in concrete or pavement.

M. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.

N. Install water-hammer arresters in water piping according to PDI-WH 201.

O. Install air vents at high points of water piping.

P. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

Q. Install trap primers in-wall behind an access panel if concealed. Trap seals are not allowed.

R. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

S. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

T. Install a water meter at the domestic water supply for each lease space.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.

4. Double-check, backflow-prevention assemblies.
5. Carbonated-beverage-machine backflow preventers.
6. Dual-check-valve backflow preventers.
7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
8. Double-check, detector-assembly backflow preventers.
9. Water pressure-reducing valves.
10. Calibrated balancing valves.
11. Primary, thermostatic, water mixing valves.
12. Manifold, thermostatic, water mixing-valve assemblies.
13. Photographic-process, thermostatic, water mixing-valve assemblies.
14. Primary water tempering valves.
15. Outlet boxes.
16. Hose stations.
17. Supply-type, trap-seal primer valves.
18. Trap-seal primer systems.

- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Test each reduced-pressure-principle backflow preventer double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 22 13 16 - SANITARY WASTE AND VENT 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. Hub-and-spigot, cast-iron soil pipe and fittings.
 - 2. Copper tube and fittings.
 - 3. Specialty pipe fittings.
- B. Related Requirements:
 - 1. Section 221313 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include plans, elevations, sections, and details.

1.4 FIELD CONDITIONS

- A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than five business days in advance of proposed interruption of sanitary waste service.
 - 2. Do not proceed with interruption of sanitary waste service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).

2.2 PIPING MATERIALS

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service and Extra Heavy class(es).
- B. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L and Type M (ASTM B 88M, Type B and Type C), water tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- C. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 - 1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 - 2. Unshielded, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1173.
 - b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - c. End Connections: Same size as and compatible with pipes to be joined.
 - d. Sleeve Materials:
 - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.

- 3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
 3. Shielded, Nonpressure Transition Couplings:
 - a.
 - b. Standard: ASTM C 1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. End Connections: Same size as and compatible with pipes to be joined.
 4. Pressure Transition Couplings:
 - a. Standard: AWWA C219.
 - b. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - c. Center-Sleeve Material: Manufacturer's standard.
 - d. Gasket Material: Natural or synthetic rubber.
 - e. Metal Component Finish: Corrosion-resistant coating or material.
- B. Dielectric Fittings:
1. Dielectric Unions:
 - a. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous.
 2. Dielectric Flanges:
 - a. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.
 - 3) Pressure Rating: 150 psig (1035 kPa).
 - 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
 3. Dielectric-Flange Insulating Kits:
 - a. Description:
 - 1) Nonconducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel backing washers.
 4. Dielectric Nipples:
 - a. Description:
 - 1) Standard: IAPMO PS 66.

- 2) Electroplated steel nipple.
- 3) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
- 4) End Connections: Male threaded or grooved.
- 5) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 2. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Condensate is prohibited in grease waste lines.
- E. Locate a test well on the sanitary sewer line downstream of the grease waste and sanitary sewer line connection.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping to permit valve servicing.
- H. Install piping at indicated slopes.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install piping to allow application of insulation.
- L. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
 1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.

2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
 - a. Straight tees, elbows, and crosses may be used on vent lines.
 3. Do not change direction of flow more than 90 degrees.
 4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of waste piping in direction of flow is prohibited.
- M. Lay buried building waste piping beginning at low point of each system.
1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 3. Maintain swab in piping and pull past each joint as completed.
- N. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
1. Building Sanitary Waste: 2 percent downward in direction of flow for piping **NPS 3 (DN 80)** and smaller; 1 percent downward in direction of flow for piping **NPS 4 (DN 100)** and larger.
 2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- O. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- P. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- Q. Plumbing Specialties:
1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
 - a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
 - b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
 2. Install drains in sanitary waste gravity-flow piping.
 - a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."
- R. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- S. Install sleeves for piping penetrations of walls, ceilings, and floors.
1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

- T. Install sleeve seals for piping penetrations of concrete walls and slabs.
 - 1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 - 1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.
- B. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Dielectric Fittings:
 - 1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - 2. Dielectric Fittings for **NPS 2 (DN 50)** and Smaller: Use dielectric nipples.
 - 3. Dielectric Fittings for **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Use dielectric flange kits or nipples.
 - 4. Dielectric Fittings for **NPS 5 (DN 125)** and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

- A. Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 3. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 4. Install individual, straight, horizontal piping runs:
 - a. **100 Feet (30 m)** and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than **100 Feet (30 m)**: MSS Type 43, adjustable roller hangers.
 - c. Longer Than **100 Feet (30 m)** if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 6. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting[, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
 6. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
- G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 4. NPS 3 and NPS 5 (DN 80 and DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
- H. Install supports for vertical copper tubing every 10 feet (3 m).
- I. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect waste and vent piping to the following:
 - 1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Comply with requirements for cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
 - 6. Equipment: Connect waste piping as indicated.
 - a. Provide shutoff valve if indicated and union for each connection.
 - b. Use flanges instead of unions for connections **NPS 2-1/2 (DN 65)** and larger.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping **NPS 2 (DN 50)** and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping **NPS 2-1/2 (DN 65)** and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping.
- B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
 - a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
 - a. Close openings in piping system and fill with water to point of overflow, but not less than **10-foot head of water (30 kPa)**.
 - b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
 - c. Inspect joints for leaks.
 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
 - a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of **1-inch wg (250 Pa)**.
 - b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
 - c. Air pressure must remain constant without introducing additional air throughout period of inspection.
 - d. Inspect plumbing fixture connections for gas and water leaks.
 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil and waste piping **NPS 2-1/2 (DN 65)** and smaller shall be any of the following:
 - 1. Copper Type M tube, copper drainage fittings, and soldered joints.
- C. Aboveground, soil and waste piping **NPS 3 (DN 80)** and larger shall be the following:
 - 1. Service class, cast-iron soil pipe and fittings; caulking materials and caulked joints.
- D. Aboveground, vent piping **NPS 2-1/2 (DN 65)** and smaller shall be the following:
 - 1. Copper Type M tube, copper drainage fittings, and soldered joints.
- E. Aboveground, vent piping **NPS 3 (DN 80)** and larger shall be the following:
 - 1. Service class, cast-iron soil pipe and fittings; caulking materials; and caulked joints.
- F. Underground, soil, waste, and vent piping shall be the following:
 - 1. Extra Heavy class, cast-iron soil piping; caulking materials; and caulked joints.

END OF SECTION 221316

SECTION 22 13 19 - SANITARY WASTE 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:
 - 1. Cleanouts.
 - 2. Roof flashing assemblies.
 - 3. Through-penetration firestop assemblies.
 - 4. Miscellaneous sanitary drainage piping specialties.
- B. Related Requirements:
 - 1. Section 221423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
 - 2. Section 334200 "Stormwater Conveyance" for storm drainage piping and piping specialties outside the building.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene.
- B. FOG: Fats, oils, and greases.
- C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. FOG disposal systems.
- B. Shop Drawings:
 - 1. Show fabrication and installation details for frost-resistant vent terminals.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

- A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary waste piping specialty components.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

2.2 CLEANOUTS

- A. Cast-Iron Exposed, Interior Floor Cleanouts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
 - 2. Model Number: Z1400-HD
 - 3. Standard: ASME A112.36.2M for adjustable housing cleanout.
 - 4. Size: Same as connected branch.
 - 5. Type: Adjustable housing.
 - 6. Body or Ferrule: Dura-coated Cast iron.
 - 7. Clamping Device: Not required.
 - 8. Outlet Connection: Threaded.
 - 9. Closure: Gas and watertight ABS tapered thread plug. Adjustable Housing Material: Cast iron with threads.
 - 10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
 - 11. Frame and Cover Shape: Round.
 - 12. Top Loading Classification: Extra Heavy Duty.
 - 13. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.
- B.
- C. Wall Cleanouts:
 - 1. Manufacturer: Zurn
 - 2. Model Number: Z1468-VP
 - 3. Standard: ASME A112.36.2M. Include wall access.
 - 4. Size: Same as connected drainage piping.
 - 5. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 - 6. Closure Plug:

- a. Brass or Bronze.
 - b. **Raised** head.
 - c. Drilled and threaded for cover attachment screw.
 - d. Size: Same as or not more than one size smaller than cleanout size.
 7. Wall Access: Round, **stainless-steel** cover plate with screw.
 8. Wall Access: **Round stainless-steel** wall-installation frame and cover.
- D. Exposed, Exterior, Grade-Level Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
 2. Model Number: Z1400
 3. Standard: ASME A112.36.2M for adjustable housing cleanout.
 4. Size: Same as connected branch.
 5. Type: **Adjustable housing**.
 6. Body or Ferrule: Dura-coated Cast iron.
 7. Clamping Device: Not required.
 8. Outlet Connection: Threaded.
 9. Closure: Gas and watertight ABS tapered thread plug.
 10. Adjustable Housing Material: Cast iron with threads.
 11. Frame and Cover Material and Finish: Dura-coated cast iron top adjustable to adjacent grade.
 12. Frame and Cover Shape: Round.
 13. Top Loading Classification: Extra Heavy Duty.
 14. Riser:
 - a. Installed in asphalt: ASTM A48, class 308 grey cast-iron
 - b. Installed in other materials other than asphalt: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

2.3 ROOF FLASHING ASSEMBLIES

- A. Roof Flashing Assemblies:
1. Description: Manufactured assembly made of **6.0-lb/sq. ft. (30-kg/sq. m)**, **0.0938-inch- (2.4-mm-)** thick, lead flashing collar and skirt extending at least **8 inches (200 mm)** from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
 - a. Open-Top Vent Cap: Without cap.
 - b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
 - c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

- A. Through-Penetration Firestop Assemblies:
1. Standard: UL 1479 assembly of sleeve-and-stack fitting with firestopping plug.
 2. Size: Same as connected soil, waste, or vent stack.
 3. Sleeve: Molded-PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

4. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
5. Special Coating: Corrosion resistant on interior of fittings.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
 - a. NPS 2 (DN 50): 4-inch- (100-mm-) minimum water seal.
 - b. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

B. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

C. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches (51 mm) <Insert dimension> above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

D. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

E. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Frost-Resistant Vent Terminals:

1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.

2. Design: To provide 1-inch (25-mm) enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

G. Expansion Joints:

1. Standard: ASME A112.6.4.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.6 MOTORS

A. General requirements for motors are specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, motor shall be large enough, so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Comply with requirements for vibration-isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.
5. Locate in accessible locations.
6. All cleanouts installed in walls or other painted surfaces shall be furnished in prime coat to be painted on the job to match the mounting surface.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. For cleanouts installed exterior to the building, cleanouts shall be encased in a 24" x 24" x 6" service box unless installed in a walk, drive, or other paved area.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

- G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."
- H. Install through-penetration firestop assemblies in plastic **[conductors]** **[and]** **[stacks]** at floor penetrations.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping."
- I. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- K. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
- L. Install vent caps on each vent pipe passing through roof.
- M. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain **1-inch (25-mm)** clearance between vent pipe and roof substrate.
- N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- O. Install frost-proof vent caps on each vent pipe passing through roof. Maintain **1-inch (25-mm)** clearance between vent pipe and roof substrate.
- P. Install wood-blocking reinforcement for wall-mounting-type specialties.
- Q. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

- A. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."
- B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.
- C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
- D. Set flashing on floors and roofs in solid coating of bituminous cement.
- E. Secure flashing into sleeve and specialty clamping ring or device.
- F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."
- G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections, and prepare test reports.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled FOG disposal systems and their installation, including piping and electrical connections, and to assist in testing.
- B. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

SECTION 22 13 19.13 - SANITARY DRAINS

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. Floor drains.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene styrene.
- B. FRP: Fiberglass-reinforced plastic.
- C. HDPE: High-density polyethylene.
- D. PE: Polyethylene.
- E. PP: Polypropylene.
- F. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

- A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains for installation in restrooms:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
2. Model: Z-415-6B-P
3. Standard: ASME A112.6.3.
4. Pattern: Floor drain.
5. Body Material: Dura-coated cast-iron.
6. Seepage Flange: Not required.
7. Anchor Flange: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Not required.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Nickel bronze.
13. Top of Body and Strainer Finish: Nickel bronze.
14. Top Shape: Round.
15. Dimensions of Top or Strainer: 6 Inches.
16. Top Loading Classification: Light Duty.
17. Funnel: Not required.
18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
19. Trap Material: Cast iron.
20. Trap Pattern: Standard P-trap.
21. Trap Features: Trap-seal primer valve drain connection.
22. Trap Primer: Pro-Set Systems, Inc. trap guard fitted to match floor drain.

B. Cast-Iron Floor Drains for installation in Floral, Vestibule, Janitor Closets and Loading Dock:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
2. Model: Z-415-HD-6B-P
3. Standard: ASME A112.6.3.
4. Pattern: Floor drain.
5. Body Material: Dura-coated cast-iron.
6. Seepage Flange: Not required.
7. Anchor Flange: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Not required.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Nickel bronze.
13. Top of Body and Strainer Finish: Nickel bronze.
14. Top Shape: Round.

15. Dimensions of Top or Strainer: 6 Inches.
 16. Top Loading Classification: Heavy Duty.
 17. Funnel: Not required.
 18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
 19. Trap Material: Cast iron.
 20. Trap Pattern: Standard P-trap.
 21. Trap Features: Trap-seal primer valve drain connection.
 22. Trap Primer: Pro-Set Systems, Inc. trap guard fitted to match floor drain.
- C. Cast-Iron Floor Drains for installation in Water Service Rooms and rooms with domestic hot water storage tank:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zum Industries, LLC.
 2. Model: Z-566
 3. Standard: ASME A112.6.3.
 4. Pattern: Floor drain.
 5. Body Material: Dura-coated cast-iron.
 6. Seepage Flange: Not required.
 7. Anchor Flange: Not required.
 8. Outlet: Bottom.
 9. Backwater Valve: Not required.
 10. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel.
 11. Sediment Bucket: Not required.
 12. Top or Strainer Material: Cast-iron.
 13. Shape: Square.
 14. Dimensions: 12 Inches by 12 inches.
 15. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
 16. Trap Material: Cast iron.
 17. Trap Pattern: Standard P-trap.
 18. Trap Features: Trap-seal primer valve drain connection.
 19. Trap Primer: Pro-Set Systems, Inc. trap guard fitted to match floor drain.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage
 3. Set with grates depressed according to the following drainage area radii:

- a. Radius, **30 Inches (750 mm)** or Less: Equivalent to 1 percent slope, but not less than **1/4-inch (6.35-mm)** total depression.
 - b. Radius, **30 to 60 Inches (750 to 1500 mm)**: Equivalent to 1 percent slope.
 - c. Radius, **60 Inches (1500 mm)** or Larger: Equivalent to 1 percent slope, but not greater than **1-inch (25-mm)** total depression.
- 4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
- 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- B. Install open drain fittings with top of hub **2 inches (51 mm)** above floor.

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.
- C. Comply with requirements in Section 221323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.
- D. Install piping adjacent to equipment to allow service and maintenance.
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 22 13 23 - SANITARY WASTE INTERCEPTORS

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. Grease interceptors.

1.3 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.
- B. PP: Polypropylene plastic.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of metal and plastic interceptor. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
- B. Shop Drawings: For each type and size of precast concrete interceptor indicated.
 - 1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Piping connections. Include size, location, and elevation of each.
 - 2. Interface with underground structures and utility services.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:
1. Notify Construction Manager no fewer than five business days in advance of proposed interruption of service.
 2. Do not proceed with interruption of sewer services without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

- A. Steel Grease Interceptors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Rockford Sanitary Systems, Inc.
 - b. Jay R. Smith Mfg. Co.
 - c. MIFAB, Inc.
 2. Standard: ASME A112.14.3 and PDI-G101, for intercepting and retaining fats, oils, and greases from food-preparation wastewater.
 3. Plumbing and Drainage Institute Seal: Not required.
 4. Body Material: Steel.
 5. Interior Lining: Corrosion-resistant enamel
 6. Exterior Coating: Corrosion-resistant enamel
 7. Body Extension: As required.
- B. Plastic Grease Interceptors:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Green Turtle Zurn.
 - b. Schier Products Company.
 2. Standard: ASME A112.14.3 and PDI-G101, for intercepting and retaining fats, oils, and greases from food-preparation wastewater.
 3. Plumbing and Drainage Institute Seal: Not required.
 4. Body Material: Plastic.
 5. Body Extension: As required.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 INSTALLATION

A. Equipment Mounting:

1. Install grease interceptors on cast-in-place concrete equipment base(s).
2. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

B. Set interceptors level and plumb.

C.

D. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor unless otherwise indicated.
2. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

A. Identification materials and installation are specified in Section 312000 "Earth Moving."

1. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
2. Use warning tapes or detectable warning tape over ferrous piping.
3. Use detectable warning tape over nonferrous piping and over edges of underground structures.

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Grease interceptors.

3.5 PROTECTION

A. Protect sanitary waste interceptors from damage during construction period.

B. Repair damage to adjacent materials caused by sanitary waste interceptor installation.

END OF SECTION 221323

SECTION 22 14 13 - FACILITY STORM DRAINAGE 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. Hub-and-spigot, cast-iron soil pipe and fittings.
- B. Related Requirements:
 - 1. Section 334400 "Stormwater Utility Equipment" for storm drainage piping outside the building.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For controlled-flow or siphonic roof drainage system. Include calculations, plans, and details.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail storm drainage piping. Show support locations, type of support, weight on each support, required clearances, 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 drainage piping will be attached or suspended from.
- B. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Construction Manager no fewer than five business days in advance of proposed interruption of storm drainage service.
2. Do not proceed with interruption of storm drainage service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 1. Storm Drainage Piping: 10-foot head of water (30 kPa).

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings:
 1. Marked with CISPI collective trademark and NSF certification mark.
 2. Class: ASTM A 74, Service and Extra Heavy class(es).
- B. Caulking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 SPECIALTY PIPE FITTINGS

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 2. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.
 - 1. Do not change direction of flow more than 90 degrees.
 - 2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of drainage piping in direction of flow is prohibited.
- K. Lay buried building piping beginning at low point of each system.
 - 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 - 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 - 3. Maintain swab in piping and pull past each joint as completed.
- L. Install piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain: 2 percent downward in direction of flow for piping **NPS 3 (DN 80)** and smaller; 1 percent downward in direction of flow for piping **NPS 4 (DN 100)** and larger.
 - 2. Horizontal Storm Drainage Piping: 2 percent downward in direction of flow.
- M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- N. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.
 - a. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
 - b. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
 - 2. Install drains in storm drainage gravity-flow piping.
 - a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

- O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors.
 - 1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
 - 1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 - 1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.
- B. Joint Restraints and Sway Bracing:
 - 1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:
 - a. Provide axial restraint for pipe and fittings **5 inches (125 mm)** and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
 - b. Provide rigid sway bracing for pipe and fittings **4 inches (100 mm)** and larger, upstream and downstream of all changes in direction 45 degrees and greater.
 - c. Provide rigid sway bracing for pipe and fittings **5 inches (125 mm)** and larger, upstream and downstream of all changes in direction and branch openings.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 - 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 6. Install individual, straight, horizontal piping runs:
 - a. **100 Feet (30 m)** and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than **100 Feet (30 m)**: MSS Type 43, adjustable roller hangers.

- c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
- 7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 - 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 - 4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 - 5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
 - 6. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.
 - 1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.
- E. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.6 IDENTIFICATION

- A. Identify exposed storm drainage piping.

- B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
 - a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure:
 - a. Test storm drainage piping on completion of roughing-in.
 - b. Close openings in piping system and fill with water to point of overflow, but not less than **10-foot head of water (30 kPa)**. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.
- C. Piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.8 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.9 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping **NPS 6 (DN 150)** and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; caulking materials; and caulked joints .
- C. Aboveground, storm drainage piping **NPS 8 (DN 200)** and larger shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; caulking materials; and caulked joints .
- D. Underground storm drainage piping **NPS 6 (DN 150)** and smaller shall be any of the following:
 - 1. Extra Heavy class, cast-iron soil pipe and fittings; caulking materials; and caulked joints.
- E. Underground, storm drainage piping **NPS 8 (DN 200)** and larger shall be any of the following:
 - 1. Extra Heavy class, cast-iron soil pipe and fittings; caulking materials; and caulked joints.

END OF SECTION 221413

SECTION 22 14 23 - STORM DRAINAGE 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:
 - 1. Metal roof drains.
 - 2. Cleanouts.
- B. Related Requirements:
 - 1. Section 076200 "Sheet Metal Flashing and Trim" for penetrations of roofs.
 - 2. Section 078413 "Penetration Firestopping" for firestopping roof penetrations.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

- A. Cast-Iron, Large-Sump, General-Purpose Roof Drains (RD-1):
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
 - 2. Model: Z100-C
 - 3. Standard: ASME A112.6.4.
 - 4. Body Material: Coated cast iron.
 - 5. Dimension of Body: Nominal 14-to 16-inch (357- to 406-mm) diameter.
 - 6. Combination Flashing Ring and Gravel Stop: Not required.

7. Flow-Control Weirs: Not required.
8. Outlet: Bottom.
9. Outlet Type: Inside caulk.
10. Extension Collars: Required.
11. Underdeck Clamp: Required.
12. Expansion Joint: Not required.
13. Sump Receiver Plate: Not required.
14. Dome Material: Cast iron.
15. Perforated Gravel Guard: Not required.
16. Vandal-Proof Dome: Required.
17. Water Dam: Not required.

B. Cast-Iron, Large-Sump, General-Purpose Roof Drains (RD-2):

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
2. Model: Z100-w2
3. Standard: ASME A112.6.4.
4. Body Material: Coated cast iron.
5. Dimension of Body: Nominal 14-to 16-inch (357- to 406-mm) diameter.
6. Combination Flashing Ring and Gravel Stop: Not required.
7. Flow-Control Weirs: Not required.
8. Outlet: Bottom.
9. Outlet Type: Inside caulk.
10. Extension Collars: Required.
11. Underdeck Clamp: Required.
12. Expansion Joint: Not required.
13. Sump Receiver Plate: Not required.
14. Dome Material: Cast iron.
15. Perforated Gravel Guard: Not required.
16. Vandal-Proof Dome: Required.
17. Water Dam: 2 inches high.

2.2 CLEANOUTS

A. Cast-Iron Exposed, Interior Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
2. Model Number: Z1400-HD
3. Standard: ASME A112.36.2M for adjustable housing cleanout.
4. Size: Same as connected branch.
5. Type: Adjustable housing.
6. Body or Ferrule: Dura-coated Cast iron.
7. Clamping Device: Not required.
8. Outlet Connection: Threaded.

9. Closure: Gas and watertight ABS tapered thread plug. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Extra Heavy Duty.
13. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

B. Wall Cleanouts:

1. Manufacturer: Zurn
2. Model Number: Z1468-VP
3. Standard: ASME A112.36.2M. Include wall access.
4. Size: Same as connected drainage piping.
5. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
6. Closure Plug:
 - a. Brass or Bronze.
 - b. Raised head.
 - c. Drilled and threaded for cover attachment screw.
 - d. Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, stainless-steel cover plate with screw.
8. Wall Access: Round stainless-steel wall-installation frame and cover.

C. Exposed, Exterior, Grade-Level Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Zurn Industries, LLC.
2. Model Number: Z1400
3. Standard: ASME A112.36.2M for adjustable housing cleanout.
4. Size: Same as connected branch.
5. Type: Adjustable housing.
6. Body or Ferrule: Dura-coated Cast iron.
7. Clamping Device: Not required.
8. Outlet Connection: Threaded.
9. Closure: Gas and watertight ABS tapered thread plug.
10. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Material and Finish: Dura-coated cast iron top adjustable to adjacent grade.
12. Frame and Cover Shape: Round.
13. Top Loading Classification: Extra Heavy Duty.
14. Riser:
 - a. Installed in asphalt: ASTM A48, class 308 grey cast-iron
 - b. Installed in other materials other than asphalt: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

D. Test Tees:

1. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301.
2. Size: Same as connected drainage piping.

3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure Plug: raised head, brass.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Install expansion joints, if indicated, in roof drain outlets.
 3. Position roof drains for easy access and maintenance.
- B. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 1. Use cleanouts the same size as drainage piping up to **NPS 4 (DN 100)**. Use **NPS 4 (DN 100)** for larger drainage piping unless larger cleanout is indicated.
 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 3. Locate cleanouts at minimum intervals of **50 feet (15 m)** for piping **NPS 4 (DN 100)** and smaller and **100 feet (30 m)** for larger piping.
 4. Locate cleanouts at base of each vertical storm piping conductor.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install test tees in vertical conductors and near floor.
- F. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- G. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.
 1. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

SECTION 22 34 00 - FUEL-FIRED, DOMESTIC-WATER HEATERS

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. Commercial, power-burner, gas-fired, storage, domestic-water heaters.
 - 2. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
 - 3. Domestic-water heater accessories.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of commercial, gas-fired and gas-fired, tankless, domestic-water heater, from manufacturer.
- B. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.
 - 1.
- C. ASME Compliance:
 - 1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: One year(s).
 - b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Power-Burner, Gas-Fired, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bock Water Heaters, Inc.
 - b. Bradford White Corporation.
 - c. PVI: A WATTS Brand.
 - d. Smith, A. O. Corporation.
2. Standard: ANSI Z21.10.3/CSA 4.3.
3. Storage-Tank Construction: Non-ASME-code steel with 150-psig (1035-kPa) working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 - b. Lining: Glass complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
4. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner: UL 795 for power-burner, gas-fired, domestic-water heaters and natural-gas fuel.
 - g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.
 - h. Temperature Control: Adjustable thermostat up to 180°F.
 - i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
5. Draft Hood: Draft diverter, complying with ANSI Z21.12.

B. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AERCO; A WATTS Brand.
 - b. Bradford White Corporation.
 - c. Lochinvar, LLC.
 - d. PVI; A WATTS Brand.
 - e. Rheem Manufacturing Company.
 - f. Smith, A. O. Corporation.
2. <Double click here to find, evaluate, and insert list of manufacturers and products.>
3. Standard: ANSI Z21.10.3/CSA 4.3.
4. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
5. Storage-Tank Construction: ASME-code steel with [150-psig (1035-kPa)] minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 - b. Lining:: Glass] complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
6. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel. Temperature Control: Adjustable thermostat.
 - g. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - h. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
7. Draft Hood: Draft diverter, complying with ANSI Z21.12

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Honeywell.
 - c. Pentair Pump Group.
 - d. Smith, A. O. Corporation.
 - e. TACO Comfort Solutions, Inc.
2. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.

- B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than **NPS 3/4 (DN 20)** with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

- C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

- D. Heat-Trap Fittings: ASHRAE 90.2.

- E. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

1. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."

- F. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.

- G. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Pressure rating as required to match gas supply.

- H. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.

- I. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.

- J. Pressure Relief Valves: Include pressure setting less than domestic-water heater working-pressure rating.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.
- 2.

K. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters and storage tanks to minimum of one and one-half times pressure rating before shipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 1. Maintain manufacturer's recommended clearances.
 2. Arrange units so controls and devices that require servicing are accessible.
 3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 6. Install anchor bolts to elevations required for proper attachment to supported equipment.
 7. Anchor domestic-water heaters to substrate.
- B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General Duty Valves,"
- C. Install gas-fired, domestic-water heaters according to NFPA 54.
 1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.

2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
 4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 231123 "Facility Natural-Gas Piping."
- D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge to floor drain.
- E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains.
- F. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- G. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.
- H. Fill domestic-water heaters with water.
- I. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

- A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
- B. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

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.

2. Leak Test: After installation, charge system 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 operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
- C. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage domestic-water heaters.

END OF SECTION 223400

SECTION 22 42 13.13 - COMMERCIAL WATER CLOSETS

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. Water closets.
 - 2. Flushometer valves.
 - 3. Toilet seats.
 - 4. Supports.

1.3 DEFINITIONS

- A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.
- B. Remote Water Closet: Located more than 30 feet (9.1 m) from other drain line connections or fixture and where less than 1.5 drainage fixture units are upstream of the drain line connection.

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 water closets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

- A. Water Closets: Floor mounted, bottom outlet, top spud.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. TOTO USA, INC.
 - 2. Bowl:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Type: Siphon jet.
 - d. Style: Flushometer valve.
 - e. Height: Refer to plans.
 - f. Rim Contour: Elongated.
 - g. Water Consumption: **1.28 gal. (4.8 L)** per flush.
 - h. Spud Size and Location: **NPS 1-1/2 (DN 40)**; top.
 - i. Color: White.
 - 3. Bowl-to-Drain Connecting Fitting: ASME A112.4.3.
 - 4. Flushometer Valve: See below.
 - 5. Toilet Seat: See below.

2.2 FLUSHOMETER VALVES

- A. Hard-Wired, Solenoid-Actuator, Piston Flushometer Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Sloan Valve Company.
 - c. TOTO USA, INC.
 - 2. Standard: ASSE 1037.

3. Minimum Pressure Rating: **125 psig (860 kPa)**.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed.
9. Actuator: Solenoid complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
10. Trip Mechanism: Hard-wired electronic sensor complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
11. Consumption: **1.28 gal. (4.8 L)** per flush.
12. Minimum Inlet: **NPS 1 (DN 25)**.
13. Minimum Outlet: **NPS 1-1/4 (DN 32)**.

2.3 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bemis Manufacturing Company
 - b. TOTO USA, INC.
 - c. Zurn Industries, LLC.
2. Standard: IAPMO/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial (Heavy duty).
5. Shape: Elongated rim, open front.
6. Hinge: Check.
7. Hinge Material: Noncorroding metal.
8. Seat Cover: Not required.
9. Color: White.

2.4 SUPPORTS

A. Water Closet Carrier:

1. Standard: ASME A112.6.1M.
2. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

- B. Examine walls and floors for suitable conditions where water closets will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Water-Closet Installation:

- 1. Install level and plumb according to roughing-in drawings.
- 2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
- 3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

- 1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
- 2. Use carrier supports with waste-fitting assembly and seal.
- 3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
- 4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

- 1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
- 2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
- 3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
- 4. Install actuators in locations that are easy for people with disabilities to reach.
- 5. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

- 1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
- 2. Install deep-pattern escutcheons if required to conceal protruding fittings.
- 3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

- 1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
- 2. Match sealant color to water-closet color.
- 3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.
- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 22 42 13.16 - COMMERCIAL URINALS

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. Urinals.
 - 2. Flushometer valves.
 - 3. Supports.
- B. Related Requirements:
 - 1. Section 224600 "Security Plumbing Fixtures" for security urinals.

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 urinals.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Wall hung, back outlet, washout, accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. TOTO USA, INC.
2. Fixture:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Type: Washout with extended shields.
 - d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
 - e. Water Consumption: One pint per flush.
 - f. Spud Size and Location: **NPS 3/4 (DN 20)**, top.
 - g. Outlet Size and Location: **NPS 2 (DN 50)**, back.
 - h. Color: White.
3. Waste Fitting:
 - a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - b. Size: **NPS 2 (DN 50)**.
4. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights..
5. Urinal Mounting Height: As indicated on the plans, but not less than one at Handicapped/elderly according to ICC A117.1 height per restroom.

2.2 URINAL FLUSHOMETER VALVES

- A. Hard-Wired, Solenoid-Actuator, Piston Flushometer Valves:
1. Standard: ASSE 1037.
 2. Minimum Pressure Rating: **125 psig (860 kPa)**.
 3. Features: Include integral check stop and backflow-prevention device.
 4. Material: Brass body with corrosion-resistant components.
 5. Exposed Flushometer-Valve Finish: Chrome plated.
 6. Panel Finish: Chrome plated or stainless steel.
 7. Style: Exposed
 8. Actuator: Solenoid complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
 9. Trip Mechanism: Hard-wired electronic sensor complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.

10. Consumption: **0.125 gal. (0.5 L).**
11. Minimum Inlet: **NPS 3/4 (DN 20)**

2.3 Minimum Outlet: **NPS 3/4 (DN 20)**SUPPORTS

A. Type I Urinal Carrier:

1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.
- B. Examine walls and floors for suitable conditions where urinals will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

- A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed urinals and fittings.
- C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

SECTION 22 42 16.13 - COMMERCIAL LAVATORIES

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. Lavatories.
 - 2. Faucets.

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 lavatories.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Servicing and adjustments of automatic faucets.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, COUNTER-MOUNTED LAVATORIES

- A. Lavatory: Oval or Round, self-rimming, vitreous china, counter mounted.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Crane Plumbing, L.L.C.
 - c. Gerber Plumbing Fixtures LLC.
 - d. Kohler Co.
 - e. TOTO USA, INC.
 2. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Type: Self-rimming for above-counter mounting.
 - c. Nominal Size: Oval, 20 by 17 inches (508 by 432 mm).
 - d. Nominal Size: Round, 19 inches (483 mm).
 - e. Faucet-Hole Punching: One hole.
 - f. Faucet-Hole Location: Top.
 - g. Color: White.
 - h. Mounting Material: Sealant.
 3. Faucet: See below.

2.2 SOLID-BRASS, AUTOMATICALLY OPERATED LAVATORY FAUCETS LF-1

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.
- B. Lavatory Faucets: Automatic-type, hard-wired with AC power adapter, electronic-sensor-operated, mixing, solid-brass valve.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. TOTO USA, INC.
 2. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
 3. 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.
 4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 5. Body Type: Single hole.
 6. Body Material: Commercial, solid brass.
 7. Finish: Polished chrome plate.
 8. Maximum Flow Rate: 0.5 gpm (1.5 L/min.).

9. Mounting Type: Deck, concealed.
10. Spout: Rigid type.
11. Spout Outlet: Aerator.
12. Drain: Not part of faucet.

2.3 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Risers:
 1. NPS 1/2 (DN 15).
 2. Chrome-plated, soft-copper flexible tube riser.

2.4 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/4 (DN 32) offset and straight tailpiece.
- C. Trap:
 1. Size: NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32).
 2. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch- (0.30-mm-) thick stainless-steel tube to wall; and stainless-steel wall flange.

2.5 SUPPORTS

- A. Type III Lavatory Carrier:
 1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

- B. Examine counters and walls for suitable conditions where lavatories will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install lavatories level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes.

Malcolm X College – West Side Learning Center
Addition and Renovations

- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.
- D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 22 42 16.16 - COMMERCIAL SINKS

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. Service sinks.
 - 2. Handwash sinks.
 - 3. Sink faucets.
 - 4. Supply fittings.
 - 5. Waste fittings.
 - 6. Supports.
- B. Related Requirements:
 - 1. Section 224100 "Residential Plumbing Fixtures" for residential sinks.

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 sinks.
 - 2. Include rated capacities, operating characteristics and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sinks to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 SINKS

A. Sinks: Stainless steel, counter mounted.

1. Fixture:

- a. Manufacturer: Elkay
- b. Standard: ASME A112.19.3/CSA B45.4.
- c. Type: Ledge back.
- d. Number of Compartments: One.
- e. Overall Dimensions: See plans.
- f. Metal Thickness: 0.050 inch (1.3 mm).
- g. Compartment:
 - 1) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain NPS 1-1/2 (DN 40) tailpiece with stopper.
 - 2) Drain Location: Centered in compartment.

2. Faucet(s):

- a. Manufacturer and model: Provide a faucet from one of the faucet manufacturer/model combinations listed below:
 - 1) Chicago Faucets, Inc.
- b. Manual type, two-lever-handle mixing valve.
- c. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
- d. Body Material: Commercial, solid brass.
- e. Finish: Chrome plated.
- f. Maximum Flow Rate: See plans.
- g. Handle(s): Wristblade.
- h. Mounting Type: Deck, exposed.
- i. Spout Type: Rigid, solid brass with wall brace.
- j. Vacuum Breaker: Not required.
- k. Spout Outlet: Hose thread according to ASME B1.20.7.
- l. Number Required: One.
- m. Mounting: On ledge.

3. Supply Fittings:

- a. Standard: ASME A112.18.1/CSA B125.1.
- b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
 - 1) Operation: Wheel handle.
 - 2) Risers: NPS 1/2 (DN 15), chrome-plated, soft-copper flexible tube.

4. Waste Fittings:

- a. Standard: ASME A112.18.2/CSA B125.2.

b. Trap(s):

- 1) Size: **NPS 1-1/2 (DN 40)**.
- 2) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with **0.032-inch- (0.83-mm-)** thick brass tube to wall; and chrome-plated brass or steel wall flange.
- 3) Material: Stainless-steel, two-piece trap and swivel elbow with **0.012-inch- (0.30-mm-)** thick stainless-steel tube to wall; and stainless-steel wall flange.

c. Continuous Waste:

- 1) Size: **NPS 1-1/2 (DN 40)**.
- 2) Material: Chrome-plated, **0.032-inch- (0.83-mm-)** thick brass tube.

5. Mounting: On counter with sealant.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.
- B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install sinks level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-hung sinks.
- C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.
- D. Set floor-mounted sinks in leveling bed of cement grout.
- E. Install water-supply piping with stop on each supply to each sink faucet.
 1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in "Valves for Plumbing Piping"
 2. Install stops in locations where they can be easily reached for operation.
- F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

- G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of sinks, inspect and repair damaged finishes.
- B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed sinks and fittings.
- D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 22 47 13 - DRINKING FOUNTAINS

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 drinking fountains and related components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of drinking fountain.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include operating characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For drinking fountains to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 DRINKING FOUNTAINS

- A. Drinking Fountains: Stainless steel, wall mounted.
 - 1. Stainless-Steel Drinking Fountains:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Elkay Manufacturing Co.
 - 2) Filtrine Manufacturing Company.
 - 3) Oasis International; a Lynn Tilton company.
 - 2. Standards:
 - a. Comply with **[ASME A112.19.3/CSA B45.4]** **[ASME A112.19.2/CSA B45.1]**.

3. Type Receptor: With back.
4. Receptor Shape: Rectangular.
5. Back Panel: Stainless-steel wall plate behind drinking fountain.
6. Bubblers: Two, with adjustable stream regulator, located on deck.
7. Maximum water flow: 8 gph.
8. Control: Push bar.
9. Drain: Grid type with **NPS 1-1/4 (DN 32)** tailpiece.
10. Supply: **NPS 3/8 (DN 10)** with shutoff valve.
11. Waste Fitting: ASME A112.18.2/CSA B125.2, **NPS 1-1/4 (DN 32)** chrome-plated brass P-trap and waste.
12. Support: Type II water cooler carrier.
13. Drinking Fountain Mounting Height: Handicapped/elderly according to ICC A117.1.

2.2 SUPPORTS

A. Type II Water Cooler Carrier:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. WATTS.
 - e. Zurn Industries, LLC.
2. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Set pedestal drinking fountains on floor.
- C. Install recessed drinking fountains secured to wood blocking in wall construction.
- D. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

- E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
- F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Install ball or gate shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.

3.5 CLEANING

- A. After installing fixtures, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224713

SECTION 23 00 30 - ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment and variable speed drives. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment.
- B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

1.2 REFERENCES

- A. NEMA Standards MG 1: Motors and Generators.
- B. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
- C. NEMA Standard 250: Enclosures for Electrical Equipment.
- D. NEMA Standard KS 1: Enclosed Switches.
- E. Comply with National Electrical Code (NFPA 70) **2011** edition.
 - 1. Work and materials shall conform to and be executed, inspected and tested in accordance with the latest edition of the National Electric Code and with the governing rules and regulations of federal, state and local governmental agencies. References to "NEC" within the Division 23 Sections shall be considered synonymous to this electrical code.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS

- A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification sections.
- B. Provide variable speed drives from a single manufacturer, regardless of manufacturers' OEM packaging agreements.

1.5 QUALITY ASSURANCE

- A. Electrical components and materials shall be UL labeled.

PART 2 - PRODUCTS

2.1 STARTERS, ELECTRICAL DEVICES, AND WIRING

- A. Motor Starter Characteristics:
 - 1. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have proper NEMA class and division.

2. All enclosures installed in parking decks or other areas subject to exposure to salt-spray shall be Type 316 stainless steel.
 3. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
- B. Manual Switches Shall Have:
1. Pilot lights and extra positions for multi-speed motors.
 2. Overload Protection: Solid-state overload relays.
- C. Magnetic Starters:
1. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
 2. Trip-free thermal overload relays, each phase.
 3. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of other Division 23 sections.
 4. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
 5. Externally operated manual reset.
 6. Under-voltage release or protection.
- D. Motor Connections:
1. Flexible metal conduit, except where plug-in electrical cords are specifically indicated. Liquid-tight flexible metal conduit shall be used in damp or wet locations.
- E. Disconnect Switches:
1. Fusible switches: fused, (Class RK-1) each phase; heavy duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; ground wire lug brazed to enclosure; capacity and characteristics as indicated.
 2. Non-Fusible Switches: For equipment 2 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than 2 horsepower, switches shall be the same as fusible type.
 3. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have proper NEMA class and division.
 4. Amps Interrupting Capacity (AIC): Match fuse or upstream protection device.

2.2 VARIABLE SPEED DRIVES

- A. General: Variable torque AC drive consisting of a solid state adjustable frequency controller (AFC) and a performance matched energy efficient motor. The manufacturer shall provide, coordinate, and start-up the drive package to ensure both proper application of the motor to the controller and to the system. The variable speed drive shall be fully digital pulse with modulation (PWM) utilizing very large scale integration (VLSI) techniques, as well as surface mount technology for increased reliability. The entire VSD Package including all options shall be in one common cabinet with the entire assembly UL approved and listed.
1. The terms adjustable frequency controller (AFC), variable speed drive (VSD) and variable frequency drive (VFD) shall be synonymous.
- B. Adjustable Frequency Controller: Shall convert service voltage, three phase, 60 hertz utility power to adjustable voltage/frequency, three phase, AC power for stepless motor control 10 percent to 110 percent of base speed.
- C. Designed and constructed to operate within the following service conditions:

1. Elevation: To 3,300 feet without derating.
 2. Ambient Temperature Range: 0 degrees C to 40 degrees C.
 3. Atmosphere: Non-condensing relative humidity to 95 percent.
 4. AC Line Voltage Variation: -10 percent to +10 percent and +/-2 percent frequency.
 5. Ride-through power sags up to 500 mSec without a controller trip.
- D. AFC shall be selected to be compatible with motor maximum FLA nameplate rating. All components shall be horsepower rated.
- E. Circuits shall provide time derivative variable voltage and variable current protection for semi-conductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:
1. 110 percent of controller maximum sine wave current rating is exceeded for longer than one (1) minute.
 2. Output phase to phase short circuit condition.
 3. Total ground fault protection under any operating condition.
 4. High input line voltage.
 5. Low input line voltage.
 6. Loss of input phase.
 7. External fault (this protective circuit shall permit by means of terminal strip, wiring of remote N.C. safety contacts such as high duct static pressure, fire or smoke safety, etc., to shut down the drive).
- F. The following adjustments shall be available in the controller:
1. Maximum Frequency: (15 to 120 Hz) factory set at 60 Hz.
 2. Minimum Frequency: (5 to 60 Hz) factory set at 6 Hz.
 3. Adjustable Acceleration: (0.1 to 360 seconds) factory set at 20 seconds.
 4. Adjustable Deceleration: (0.1 to 360 seconds) factory set at 20 seconds.
 5. Volts/Hertz ratio factory set for service voltage at 60 Hz.
 6. Voltage offset or boost factory set at 100 percent torque.
 7. Current limit (50 percent to 100 percent sine wave current rating) factory set at 100 percent current.
- G. Door mounted operator control of AFC shall be furnished with a micro-processor based command center with a membrane keypad which allows auto/manual, start/stop, manual speed control, programming, and visual display of the units operating parameters. The microprocessor system shall be password protected and provide full monitoring, control, and diagnostics.
1. In automatic mode, controller shall follow an external signal and respond to remote start-stop contact wired to terminal strip and all safety interlocks.
 2. Digital display shall be door mounted to indicate power on, drive faults, motor running and external faults.
 3. While in auto mode the controller shall attempt to three automatic restarts (user selectable) after a power outage, drive fault or external fault. If drive does not successfully come back on line after the programmed tries it shall remain off on IET until operator diagnoses cause of shut down and manually re-establishes drive operation in the bypass (when equipped) or AFC mode of operation.
 4. Integral annunciator contact for customer remote indication of drive fault conditions.
 5. An integral "External Fault" protective shutdown circuit shall be provided for interface of firestat, smoke detectors, duct high limit pressure switches, etc. These safety interlocks shall provide shutdown of the system while operating the VFD or By-pass mode.
 6. Voltage, current and frequency display: Shall be provided to digitally indicate the output voltage, output frequency and output current.
 7. Built-in Diagnostics: Shall provide a quick means for monitoring the different signals within the AFC for start-up and troubleshooting. The diagnostics shall indicate internal and external faults

and provide digital display of inverter system faults.

H. Input Power Parameters:

1. The variable frequency controller shall accept 208/230 volts AC three phase, 60 Hz for 230V services, and 460 volts AC three phase, 60 Hz for 460 volts series. Variations of up to +/- 10 percent of line voltage and +/- 2 Hz of line frequency shall be permitted without the drive shutting down on a fault.
2. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.

I. Compliance to the Latest Edition of IEEE 519:

1. The VSD manufacturer shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 3 percent. Input line filters shall be sized and provided as required by the VSD manufacturer to ensure compliance with the latest edition of IEEE Standard 519, Guide for Harmonic Control and Reactive Compensation for Static Power Converters. The acceptance of this calculation must be completed prior to VSD installation.
2. The VSD manufacturer shall provide drives with load-side line reactors to 3% or better total harmonic distortion when the load-side feeder length is 35 feet or greater.
3. Prior to installation, the VSD manufacturer shall provide the estimated total harmonic distortion (THD) caused by the VSDs. The results shall be based on a computer aided circuit simulation of the total actual system, with information obtained from the power provided and the user.

J. Manual Bypass with Magnetic Contacts:

1. Manual bypass with magnetic contactors shall provide all the circuitry necessary to safely transfer the motor from the AFC to the power line, or from the line to the controller while the motor is at zero speed.
2. Two motor contacts, electrically interlocked, shall be utilized. One contactor shall be between the controller output and the motor, controlled by the controller regulator and the other one shall be between the bypass power line and the motor, providing across the line starting. Motor protection is to be provided in both the "controller" mode and the "bypass" mode by a thermal motor overload relay. The control logic shall allow common start/stop and all protective circuit commands in the "controller" mode and the "bypass" mode. A main power input disconnect switch shall be capable of positive shut-down of all input power to both the bypass circuitry and the AFC. This main input disconnect switch shall have provisions for pad locking in the off position for operator safety.
3. A second input disconnect switch shall allow isolation of the AFC from input power while allowing the system to operate in the bypass mode. This disconnect shall provide the ability to safely troubleshoot and test the controller, both energized and de-energized, while operating in the "bypass" mode. All components shall mount within the common controller enclosure as a factory unitized package.
4. Provide manual bypass where indicated on the drawings.

K. Enclosure:

1. Interior: Shall require front access only with both top and bottom cable entry possible and shall be NEMA 1 design.
2. Exterior or Wet Locations: NEMA Type 4X.

L. Disconnect Switches

1. General:
 - a. Disconnect switches for protection of adjustable frequency drives with engraved coverplate identifying load served.
 - b. Disconnect and fuse may be integral to the ASD enclosure or a separate adjacent enclosure.

2. Manufacturers:
 - a. Eaton Corporation; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D/Group Schneider.
 3. Construction:
 - a. Heavy duty type, fused and/or non-fusible as shown on Drawings.
 - b. Interior Construction: Switch blades fully visible in the off position when the enclosure door is open. Fuseholders for specified fuse, rejection type.
 - c. Switch Mechanism: Quick make, quick break with positive interlock to prevent opening of enclosure door when operating handle is in the on position and to prevent closing of the switch mechanism with the door open. Operating handle shall be an integral part of enclosure base, have provisions for three padlocks in the off position, and the means to indicate whether the switch is on or off by its position. Vertical operating handles shall be up in the on position.
 - d. Terminal Lugs: Suitable for quantity of wire to be attached, front removable with terminal shields; mechanical type for copper wire, compression type for aluminum wire.
 4. Ratings:
 - a. Amperes: 30 - 1200.
 - b. Voltage: 240 or 600.
 - c. Poles: 2 or 3.
 - d. AIC: Match fuse or upstream protective device.
 - e. Horsepower Rated: 30 - 600 amps.
 5. Enclosure:
 - a. Surface mounted type.
 - b. Type shall suit area per NEMA requirements.
 - c. Ground wire lug of suitable size shall be brazed to the enclosure. Neutral bar on four wire systems shall be ungrounded.
 - d. Nameplates on front shall identify load service as well as proper fuse application warning.
- M. Cartridge Type Fuses
1. Manufacturers: Copper Industries, Inc. - Bussmann, Chase-Shawnut, Economy, Littlefuse.
 2. Fuses, General:
 - a. General: Provide fuses of types, classes, and current ratings as indicated. Voltage ratings shall be consistent with the circuits on which used.
 3. Application of Fuses:
 - a. Motor Fused Disconnect Switches and Combination Controllers (AFD bypass combination starters): Class RK1, dual element time delay; LPN-RK, LPS-RK.
 - b. AFD short circuit protection; 0 - 600 Amperes: Class RK1, single element fast acting.
- N. General options/modifications shall be designed to fit in the standard enclosure while maintaining the AFC UL listing. The complete unit as a total assembly shall be UL approved and labeled.
- O. General Options/Modifications shall include:
1. Isolated Process Control Interface: Shall enable the AFC to follow a 0-5, 1-5, 4-20, 10-50, ma; 0-4, 0-8, 0-10 VDC grounded or ungrounded signal from a process controller.
 2. Input line reactors to provide additional line inductance which reduces nuisance trips from line

- surges, line notching and voltage distortion. (Refer to compliance with IEEE 519 parameters above).
- 3. Motor Overload: Shall contain a thermal overload relay designed to protect one AC motor operated on AFC output from extended overload operation. This shall be designed to mount internal to the AFC enclosure.
- 4. Provide communication card to facilitate communication with the Building Automation System (BAS). All drive parameters shall be available to the BAS through the communication card.
- P. Quality Assurance Controls, Procedures, and Tests:
 - 1. Integrated circuits tests shall include 168 hours burn-in screening at 145 degrees C according to MIL-STD-8813B, stabilization baking and temperature cycling from 150 degrees C to -40 degrees C.
 - 2. Small signal semi-conductors shall be lot samples HTRB per MIL-STD-105D (1 percent AGL).
 - 3. All SCR device assemblies of individual heatsink construction shall be electrically curve traced. Each assembly shall be loaded to 125 percent of its rated full load amperes and run for five minutes.
 - 4. Electronic printed circuit board assemblies shall be temperature cycled for 24 hours between 5 degrees C and 85 degrees C.
 - 5. AFC shall be functionally tested under motor load and then cycled under load for several hours.
- Q. Manufacturers: Subject to compliance with requirements, provide variable speed drives of one of the following:
 - 1. Asea Brown Boveri.
 - 2. Eaton.
 - 3. Yaskawa.

PART 3 - EXECUTION

3.1 WIRING

- 1. All field wiring connections under 120V shall utilize WAGO connectors.

3.2 CLOSEOUT PROCEDURES

- A. Provide services of manufacturer's technical representative for one (1) 8-hour day to instruct Owner's personnel in operation and maintenance of variable speed drives.
 - 1. Schedule training with Owner; provide at least seven (7) days' notice to Contractor and Engineer of training date.

END OF SECTION 230030

SECTION 23 05 13 - 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.

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.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. 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 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. 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.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. 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.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 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. 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.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 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: Prelubricated, 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.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS 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. Metal, compensator packless expansion joints.
 - 2. Rubber union connector packless expansion joints.
 - 3. Flexible-hose packless expansion joints.
 - 4. Rubber packless expansion joints.
 - 5. Grooved-joint expansion joints.
 - 6. Alignment guides and anchors.
 - 7. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints MCEJ-01:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hyspan Precision Products, Inc.
 - b. Mason Industries, Inc.
 - c. Metraflex Company (The).
- 2. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
- 3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
- 4. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
- 5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
 - a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.
- 6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.

B. Rubber Union Connector Expansion Joints RUEJ-01:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. General Rubber Corporation.
 - c. Mason Industries, Inc.

2. Material: Twin reinforced-rubber spheres with external restraining cables.
3. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C), unless otherwise indicated.
4. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

C. Flexible-Hose Packless Expansion Joints FHEJ-01:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. Mason Industries, Inc.
 - c. Metraflex Company (The).
2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
 - b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.
6. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
8. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Carbon-steel fittings with flanged end connections.

- a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
9. Expansion Joints for Steel Piping NPS 14 (DN 350) and Larger: Carbon-steel fittings with flanged end connections.
- a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

2.3 GROOVED-JOINT EXPANSION JOINTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Grinnell Mechanical Products.
 2. Shurjoint Piping Products USA Inc.
 3. Victaulic Company.
- B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- C. Standard: AWWA C606, for grooved joints.
- D. Nipples: Galvanized, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- E. Couplings: Seven, flexible type for steel-pipe dimensions. Include ferrous housing sections, ethylene-propylene-diene terpolymer rubber gasket suitable for cold and hot water, and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

- A. Alignment Guides AG-01:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hyspan Precision Products, Inc.
 - b. Mason Industries, Inc.
 - c. 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.
- B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A 36/A 36M.
 2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
 3. Washers: ASTM F 844, steel, plain, flat washers.
 4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

- a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
- 5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement 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: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install rubber packless expansion joints according to FSA-PSJ-703.
- C. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 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 mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 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 not more than four 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.

END OF SECTION 230516

SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS 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. Stack-sleeve fittings.
- 3. Sleeve-seal systems.
- 4. Sleeve-seal fittings.
- 5. Grout.
- 6. 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.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

- C. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- D. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg. Co.
 - 2. Zurn Industries, LLC.
- B. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description:
 - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 2. Designed to form a hydrostatic seal of 20-psig (137-kPa) minimum).
 - 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 - 4. Pressure Plates: Stainless steel.
 - 5. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Description:
 - 1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
 - 2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

- A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-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 (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

- A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.
- B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) 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 (50 mm) above finished floor level.
 - 3. Using grout or silicone sealant, seal 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 (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 3 inches (76 mm) above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls 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.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings as new walls and slabs 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 or silicone sealant, seal space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Exterior Concrete Walls Above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves.
 2. Exterior Concrete Walls Below Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 4. Concrete Slabs Above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Stack-sleeve fittings.
 5. Interior Partitions:
 - a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 230517

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 18 - 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. Escutcheons.
 - 2. Floor plates.

1.3 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.
- C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- D. Escutcheons described in "One-Piece, Deep-Pattern Type" Paragraph below are generally available in 1-1/4-inch (32-mm) OD, 1-1/2-inch (38-mm) OD, 1-1/4-inch (32-mm) IPS, and 1-1/2-inch (38-mm) IPS. The "brass" oOne-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.
- E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
- F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.2 FLOOR PLATES

- A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 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 New Piping and Relocated Existing Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Chrome-Plated Piping: One-piece steel or split-plate steel with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - g. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - 2. Escutcheons for Existing Piping to Remain:
 - a. Chrome-Plated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
- 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 and Relocated Existing Piping: Split floor plate.

Malcolm X College- West Side Learning Center
Addition and Renovations

2. Existing Piping to Remain: Split floor plate.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 230518

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 19 - 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. Duct-thermometer mounting brackets.
- 6. Thermowells.
- 7. Dial-type pressure gages.
- 8. Gage attachments.
- 9. Test plugs.
- 10. Test-plug kits.
- 11. Sight flow indicators.
- 12. Flowmeters.
- 13. Thermal-energy meters.

- B. Related Requirements:

- 1. Section 231123 "Facility Natural-Gas Piping" for gas meters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

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

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 BIMETALLIC-ACTUATED THERMOMETERS

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

- 1. Marsh Bellofram.
- 2. Miljoco Corporation.
- 3. Terice, H. O. Co.
- 4. Weksler Glass Thermometer Corp.

- B. Standard: ASME B40.200.
- C. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch (127-mm) nominal diameter.
- D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C).
- E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- F. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
- G. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
- H. Window: plastic.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1.5 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

- A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Terice, H. O. Co.
 - c. Weiss Instruments, Inc.
- 2. Standard: ASME B40.200.

3. Case: Sealed type, cast aluminum or drawn steel; 5-inch (127-mm) nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: plastic.
9. Ring: Metal.
10. 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.
11. 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.
12. Accuracy: Plus or minus 1 percent of scale range.

B. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Miljoco Corporation.
 - c. Terice, H. O. Co.
 - d. Weiss Instruments, Inc.
2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter with front flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: plastic.
9. Ring: Metal.
10. Connector Type(s): Union joint, back; with ASME B1.1 screw threads.
11. 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.
12. Accuracy: Plus or minus 1 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Terice, H. O. Co.
 - c. Weiss Instruments, Inc.
 - d. Weksler Glass Thermometer Corp.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch (229-mm) nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: plastic.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Terice, H. O. Co.
 - b. Weiss Instruments, Inc.
 - c. Weksler Glass Thermometer Corp.
2. Case: Metal; 9-inch (229-mm) nominal size unless otherwise indicated.
3. Scale(s): Deg F and deg C.
4. Case Form: Adjustable angle.
5. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
7. Display: Digital.
8. Accuracy: Plus or minus 2 deg F (1 deg C).

B. Remote-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Weiss Instruments, Inc.

2. Case: Plastic, for wall mounting.
3. Scale(s): Deg F.
4. Sensor: Bulb and thermister wire.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
5. Display: Digital.
6. Accuracy: Plus or minus 2 deg F (1 deg C).

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 in piping tee fitting.
 3. Material for Use with Copper Tubing: CNR or CUNI.
 4. Material for Use with Steel Piping: CSA.
 5. Type: Stepped shank unless straight or tapered shank is indicated.
 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
 7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), 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 DIAL-TYPE PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Marsh Bellofram.
 - b. Miljoco Corporation.
 - c. Noshok.
 - d. Palmer Wahl Instrumentation Group.
 - e. Terice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Weksler Glass Thermometer Corp.

2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: plastic.
10. Ring: Metal.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Marsh Bellofram.
 - b. Miljoco Corporation.
 - c. Noshok.
 - d. Palmer Wahl Instrumentation Group.
 - e. Trerice, H. O. Co.
 - f. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type; cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: plastic.
10. Ring: Metal.
11. 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 (DN 8 or DN 15), 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 pipe with NPS 1/4 or NPS 1/2 (DN 8 or DN 15) pipe threads.
- C. Valves: Brass ball, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), 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. Miljoco Corporation.
 2. Trerice, H. O. Co.
 3. Weiss Instruments, Inc.
 4. Weksler Glass Thermometer Corp.
- B. Description: Test-station fitting made for insertion in 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 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
- F. Core Inserts: EPDM self-sealing rubber.

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. Outside-, return-, supply-, and mixed-air ducts.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

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. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
 - 2. Direct-mounted, light-activated type.
- B. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be the following:
 - 1. Direct or remote-mounted, metal-case, vapor-actuated 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: 30 to 240 deg F and 0 to plus 115 deg C.
- B. Scale Range for Air Ducts: Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C.

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
 - 1. Liquid-filled, direct-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi and 0 to 1100 kPa.

END OF SECTION 230519

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 29 - 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 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
4. 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 and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. 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. Fiberglass strut systems.
 4. Pipe stands.
 5. 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.

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, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Unistrut, Part of Atkore International.
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 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.
7. Paint Coating: Vinyl alkyd.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa) ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) 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 (50 mm) 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 plastic 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: Plastic.
 - 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: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

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. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.
- G. 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.

- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. 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.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. 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 (DN 65) 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.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. 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.
- O. 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 if insulation without vapor barrier is indicated. 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 (DN 100) and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. 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 (DN 100) 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 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.

- e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
- 5. Pipes NPS 8 (DN 200) 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 (40 mm).

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 (0.05 mm).

- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High Performance Coatings."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

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 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 (DN 15 to DN 750).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).

9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) 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 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) 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 (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) 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-joist 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. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. 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 (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- 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 (32 mm).
 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.
- 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.

END OF SECTION 230529

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS 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. Elastomeric isolation pads.
- 2. Elastomeric isolation mounts.
- 3. Restrained elastomeric isolation mounts.
- 4. Open-spring isolators.
- 5. Housed-spring isolators.
- 6. Restrained-spring isolators.
- 7. Housed-restrained-spring isolators.
- 8. Pipe-riser resilient supports.
- 9. Resilient pipe guides.
- 10. Elastomeric hangers.
- 11. Spring hangers.
- 12. Snubbers.
- 13. Restraint channel bracings.
- 14. Restraint cables.
- 15. Mechanical anchor bolts.
- 16. Adhesive anchor bolts.
- 17. Vibration isolation equipment bases.
- 18. Restrained isolation roof-curb rails.

- B. Related Requirements:

- 1. Section 220548 "Vibration and Seismic Controls for Plumbing" for devices for plumbing equipment and systems.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device.
 - a. Annotate to indicate application of each product submitted and compliance with requirements.
 3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 2. 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.
- C. Delegated-Design Submittal: For each vibration isolation device.
1. Include design calculations and details for selecting vibration isolators, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and wind forces required to select vibration isolators and wind restraints and for designing vibration isolation bases.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.
 4. Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure. Indicate association with vibration isolation devices.
 - c. Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For professional engineer.
- C. Welding certificates.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
 - 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - 3. Size: Factory or field cut to match requirements of supported equipment.
 - 4. Pad Material: Oil and water resistant with elastomeric properties.
 - 5. Surface Pattern: Ribbed pattern.
 - 6. Infused nonwoven cotton or synthetic fibers.
 - 7. Sandwich-Core Material: Resilient and elastomeric.
 - a. Surface Pattern: Ribbed pattern.
 - b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS

- A. Double-Deflection, Elastomeric Isolation Mounts: .
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
2. Description: All-directional isolator containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
2. Outside 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. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
2. Outside 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. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top housing with attachment and leveling bolt.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
 2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 PIPE-RISER RESILIENT SUPPORT

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.9 RESILIENT PIPE GUIDES

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.11 SPRING HANGERS

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
 2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.12 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Kinetics Noise Control, Inc.
 2. Mason Industries, Inc.
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Anchor bolts for attaching to concrete shall be drill-in, and stud-wedge or female-wedge type.
 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.13 RESTRAINT CHANNEL BRACINGS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; Part of Atkore International.

- B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.14 RESTRAINT CABLES

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

1. Gripple Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

- B. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.15 MECHANICAL ANCHOR BOLTS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

- B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.16 ADHESIVE ANCHOR BOLTS

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

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

- B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.17 VIBRATION ISOLATION EQUIPMENT BASES

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

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Vibro-Acoustics
4. Thybar Corporation

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
 - a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.18 RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Kinetics Noise Control, Inc.
 - 2. Mason Industries, Inc.
 - 3. Vibro-Acoustics
 - 4. Thybar Corporation.
- B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand wind forces.
- C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind forces.
- D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches (50 mm) of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
- E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.
- F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods.

3.3 VIBRATION CONTROL DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
- E. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- J. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 FIELD QUALITY CONTROL

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

3.5 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.6 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

END OF SECTION 230548

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Kolbi Pipe Marker Co.
 - c. Seton Identification Products.
 - 2. Material and Thickness: Anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 3. Letter Color: White.
 - 4. Background Color: Black or Blue.

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.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Kolbi Pipe Marker Co.
 - c. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black or Blue.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. 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.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. 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.

2.2 WARNING SIGNS AND LABELS

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

1. Brady Corporation.
2. Marking Services Inc.
3. Seton Identification Products.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: White.

- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. 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.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full 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; also include pipe size and an arrow indicating flow direction.
 - 1. 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.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 DUCT LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Black.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. 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.
- H. Fasteners: Stainless-steel rivets.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products.
- B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch stainless steel, 0.025-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass beaded chain or S-hook.
- C. 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.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches.

2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-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 GENERAL INSTALLATION REQUIREMENTS

- 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.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Pipe Label Locations: Locate pipe labels where piping is exposed or 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 and on both sides of 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 feet 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: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

- D. Pipe Label Color Schedule:
 - 1. Refrigerant Piping: Black letters on a safety-orange background.

3.5 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 - 1. Blue: For cold-air supply ducts.
 - 2. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
- B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Refrigerant: 2 inches, round.
 - b. Gas: 2 inches, round.
 - 2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
 - b. Flammable Fluids: Black letters on a safety-yellow background.
 - c. Combustible Fluids: White letters on a safety-brown background.
 - d. Potable and Other Water: White letters on a safety-green background.
 - e. Compressed Air: White letters on a safety-blue background.
 - f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.7 WARNING-TAG INSTALLATION

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

END OF SECTION 23 0553

SECTION 23 05 93 - 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. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.
- 3. Testing, Adjusting, and Balancing Equipment:
 - a. Motors.
 - b. Condensing units.
 - c. Heat-transfer coils.
 - d. Variable Air Volume Terminal Units
 - e. Dedicated outside air units (DOAS)
 - f. Variable Refrigerant Flow (VRF) Fan Coil Units
- 4. Testing, adjusting, and balancing existing systems and equipment.
- 5. Sound tests.
- 6. Vibration tests.
- 7. Duct leakage tests.
- 8. 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 Owner, 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. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- C. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- D. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- E. Certified TAB reports.
- F. Sample report forms.
- G. 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.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
- B. TAB Specialists Qualifications: Certified by NEBB or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.8 FIELD CONDITIONS

- A. 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 system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. 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.

2. Hydronics:

- a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
- b. Piping is complete with terminals installed.
- c. Water treatment is complete.
- d. Systems are flushed, filled, and air purged.
- e. Strainers are pulled and cleaned.
- f. Control valves are functioning per the sequence of operation.
- g. Shutoff and balance valves have been verified to be 100 percent open.
- h. Pumps are started and proper rotation is verified.
- i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- j. Variable-frequency controllers' startup is complete and safeties are verified.
- k. 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, and/or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" 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, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - 3. 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 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."

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 Owner 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 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.

3.8 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

- A. 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 SOUND TESTS

- A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 15 locations as designated by the Architect.
- B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches (900 mm) from a wall or from the operating equipment and approximately 60 inches (1500 mm) from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
 - a. Location.
 - b. System tested.
 - c. dBA reading.
 - d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on NC worksheet with equipment on and off.

3.11 VIBRATION TESTS

- A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 15.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.12 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.13 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.

3.14 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

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

3.15 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.

3.16 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 weekly 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.

3.17 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. 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 (mm), and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 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 (mm), and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm (L/s).
- b. Total system static pressure in inches wg (Pa).
- c. Fan rpm.
- d. Discharge static pressure in inches wg (Pa).
- e. Filter static-pressure differential in inches wg (Pa).
- f. Preheat-coil static-pressure differential in inches wg (Pa).
- g. Cooling-coil static-pressure differential in inches wg (Pa).
- h. Heating-coil static-pressure differential in inches wg (Pa).
- i. Outdoor airflow in cfm (L/s).
- j. Return airflow in cfm (L/s).
- 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 (mm) o.c.
- f. Make and model number.
- g. Face area in sq. ft. (sq. m).
- h. Tube size in NPS (DN).
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

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

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and unit size.
- e. Manufacturer's serial number.
- f. Fuel type in input data.
- g. Output capacity in Btu/h (kW).
- h. Ignition type.
- i. Burner-control types.
- j. Motor horsepower and rpm.
- k. Motor volts, phase, and hertz.
- l. Motor full-load amperage and service factor.
- m. Sheave make, size in inches (mm), and bore.
- n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm (L/s).
- b. Entering-air temperature in deg F (deg C).
- c. Leaving-air temperature in deg F (deg C).
- d. Air temperature differential in deg F (deg C).
- e. Entering-air static pressure in inches wg (Pa).
- f. Leaving-air static pressure in inches wg (Pa).
- g. Air static-pressure differential in inches wg (Pa).
- h. Low-fire fuel input in Btu/h (kW).
- i. High-fire fuel input in Btu/h (kW).
- j. Manifold pressure in psig (kPa).
- k. High-temperature-limit setting in deg F (deg C).
- l. Operating set point in Btu/h (kW).
- m. Motor voltage at each connection.
- n. Motor amperage for each phase.
- o. Heating value of fuel in Btu/h (kW).

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 (mm), and bore.
- h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

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 (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
- 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).
- 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 (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated airflow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual airflow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).
- 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. (sq. m).
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary airflow rate as needed in cfm (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final airflow rate in cfm (L/s).

- f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).
 - 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 (L/s).
 - b. Entering-water temperature in deg F (deg C).
 - c. Leaving-water temperature in deg F (deg C).
 - d. Water pressure drop in feet of head or psig (kPa).
 - e. Entering-air temperature in deg F (deg C).
 - f. Leaving-air temperature in deg F (deg C).
 - 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.
- 3.18 VERIFICATION OF TAB REPORT
- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner.
 - B. Owner 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.

3.19 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

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 07 13 - DUCT INSULATION

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 insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Outdoor, concealed supply and return.
 - 6. Outdoor, exposed supply and return.
- B. Related Sections:
 - 1. Section 230719 "HVAC Piping Insulation."
 - 2. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 - 3. Detail application of field-applied jackets.
 - 4. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Owens Corning.
- H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Owens Corning.
- I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40

kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

- a. CertainTeed Corporation.
- b. Johns Manville; a Berkshire Hathaway company.
- c. Knauf Insulation.
- d. Owens Corning.

J. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

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

- a. Armacell LLC.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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

- a. Johns Manville; a Berkshire Hathaway company.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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

- a. 3M.
- b. CertainTeed Corporation.
- c. Johns Manville; a Berkshire Hathaway company.
- d. Nelson Firestop; a brand of Emerson Industrial Automation.
- e. Thermal Ceramics.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

- a. Aeroflex USA, Inc.

b. Armacell LLC.

- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 - 2. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 3. Solids Content: 60 percent by volume and 66 percent by weight.
 - 4. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 - 2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).

3. Color: White.

2.6 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: Aluminum.
- B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: White.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: Color-code jackets based on system. Color as selected by Architect.
- D. Metal Jacket:
 1. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.

- b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
- 2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
- E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 11.5 mils (0.29 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 6.5 mils (0.16 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 6 mils (0.15 mm).
 - 3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches (50 mm).

2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.10 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

2.11 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 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 (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. 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 (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
1. Comply with requirements in Section 078413 "Penetration Firestopping."
- E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. 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.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
 5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.9 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Outdoor, concealed supply and return.
 - 6. Outdoor, exposed supply and return.
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- B. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.

- C. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch (25 mm) thick.
 - 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
 - 4. Polyolefin: 1 inch (25 mm) thick.
- D. Concealed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- E. Concealed, rectangular, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- F. Concealed, rectangular, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- G. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- H. Concealed, supply-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- I. Concealed, return-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- J. Concealed, outdoor-air plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- K. Concealed, exhaust-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- L. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- M. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- N. Exposed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
- O. Exposed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.

2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- P. Exposed, rectangular, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- Q. Exposed, rectangular, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- R. Exposed, rectangular, outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- S. Exposed, supply-air plenum insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
- T. Exposed, return-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- U. Exposed, outdoor-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- V. Exposed, exhaust-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- 3.13 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE
- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Concealed, round and flat-oval, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **[6-lb/cu. ft. (96-kg/cu. m)]** nominal density.
- C. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m)] nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- D. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- E. Concealed, rectangular, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

- F. Concealed, rectangular, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- G. Concealed, supply-air plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- H. Concealed, return-air plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- I. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - 3. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
- J. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- K. Exposed, rectangular, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 2 inches (50 mm) and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- L. Exposed, rectangular, return-air duct insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- M. Exposed, supply-air plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- N. Exposed, return-air plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. None.
- D. Ducts and Plenums, Piping, Exposed in Food Preparation Areas:
 - 1.

2. Aluminum, Stucco Embossed: 0.016 inch (0.41 mm) thick.
3. Stainless Steel, Type 304, Smooth 2B Finish or Stucco Embossed: 0.010 inch (0.25 mm) thick.

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 1. None.
- D. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 1. Aluminum, Stucco Embossed: 0.020 inch (0.51 mm) thick.
 2. Stainless Steel, Type 304 or Type 316, Smooth 2B Finish or Stucco Embossed: 0.016 inch (0.41 mm) thick.
- E. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 1. Stainless Steel, Type 304 or Type 316, Smooth or Stucco Embossed, with 1-1/4-Inch- (32-mm-) Deep Corrugations or 4-by-1-Inch (100-by-25-mm) Box Ribs: 0.020 inch (0.51 mm) thick.

END OF SECTION 230713

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 07 19 - HVAC PIPING INSULATION

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 insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors and outdoors.
 - 2. Refrigerant suction and hot-gas piping, indoors and outdoors.
 - 3. Heated fuel-oil piping, outdoors.
- B. Related Sections:
 - 1. Section 230713 "Duct Insulation."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Block Insulation: ASTM C 552, Type I.
 - 2. Special-Shaped Insulation: ASTM C 552, Type III.
 - 3. Board Insulation: ASTM C 552, Type IV.
 - 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - 5. Preformed Pipe Insulation with Factory-Applied **[ASJ]** **[ASJ-SSL]**: Comply with ASTM C 552, Type II, Class 2.
 - 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
- H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Knauf Insulation.
 - c. Owens Corning.
 - 2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

3. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- J. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.
- K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- L. Phenolic:
 1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Preformed Pipe Insulation: ASJ.
- M. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
 1. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 2. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thickness up to 1 inch (25 mm) as tested by ASTM E 84.
 3. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Pipe Applications: ASJ.
- N. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
- O. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
- C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).
- D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
- E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
- H. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- I. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 - 2. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 2. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 3. Solids Content: 60 percent by volume and 66 percent by weight.
 4. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
 3. Color: White.

2.6 SEALANTS

- A. Cellular-Glass, Phenolic, and Polyisocyanurate Joint Sealants:
- B. Polystyrene Joint Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Permanently flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 4. Color: White or gray.
- C. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: Aluminum.
- D. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: White.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

2.10 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: Color-code jackets based on system. Color as selected by Architect.
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

- a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- D. Metal Jacket:
- 1. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 - 2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
- F. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized

bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

- G. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
- H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 11.5 mils (0.29 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 6.5 mils (0.16 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 6 mils (0.15 mm).
 - 3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 3.7 mils (0.093 mm).
 - 3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Width: 3 inches (75 mm).
 - 2. Film Thickness: 4 mils (0.10 mm).
 - 3. Adhesive Thickness: 1.5 mils (0.04 mm).
 - 4. Elongation at Break: 145 percent.

5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.
- F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches (75 mm).
 2. Film Thickness: 6 mils (0.15 mm).
 3. Adhesive Thickness: 1.5 mils (0.04 mm).
 4. Elongation at Break: 145 percent.
 5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.12 SECUREMENTS

- A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
 2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with wing seal or closed seal.
 3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- C. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Manholes.
 5. Handholes.
 6. Cleanouts.

3.4 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 (50 mm) 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 (50 mm).
 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 Section 078413 "Penetration Firestopping" 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 Section 078413 "Penetration Firestopping."

3.5 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.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. 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.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, 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.
3. Install insulation to flanges as specified for flange insulation application.
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.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.

2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.11 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
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.

3.12 INSTALLATION OF POLYSTYRENE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm).
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.13 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

- B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.
- E. Where PVDC jackets are indicated, install as follows:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 2. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.14 FINISHES

- A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

- a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.15 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.16 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.17 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 3/4 inch (19 mm) thick.
 - c. Phenolic: 1 inch (25 mm) thick.
 - d. Polyisocyanurate: 1 inch (25 mm) thick.
 - e. Polyolefin: 3/4 inch (19 mm) thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - d. Phenolic: 1 inch (25 mm) thick.
 - e. Polyisocyanurate: 1 inch (25 mm) thick.
 - f. Polyolefin: 1 inch (25 mm) thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Polyolefin: 1 inch (25 mm) thick.

3.18 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 2 inches (50 mm) thick.
 - c. Phenolic: 2 inches (50 mm) thick.
 - d. Polyisocyanurate: 2 inches (50 mm) thick.
 - e. Polyolefin: 2 inches (50 mm) thick.
 - f. Polystyrene: 2 inches (50 mm) thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 2 inches (50 mm) thick.
 - b. Polyolefin: 2 inches (50 mm) thick.

C. Fuel Oil Piping, Heated:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.

3.19 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

- A. Loose-fill insulation, for belowground piping, is specified in Section 232113.13 "Underground Hydronic Piping" and Section 336313 "Underground Steam and Condensate Distribution Piping."
- B. Fuel Oil Piping, All Sizes, Heated: Cellular glass, 2 inches (50 mm) thick.

3.20 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed in Food Preparation Areas and in walk-in coolers shall be one of the following:
 - 1. PVC, Color-Coded by System: 20 mils (0.5 mm) thick. Provide formed PVC cover 30 mils thick for all valves, fittings, and flanges.
 - 2. Aluminum, Smooth Corrugated or Stucco Embossed: 0.016 inch (0.41 mm) thick. Provide formed aluminum cover 0.02400 thick for all valves, fittings, and flanges.
 - 3. Stainless Steel, Type 304, **Smooth 2B Finish, Corrugated** or **Stucco Embossed: 0.016 inch (0.41 mm)** thick. Provide formed stainless steel cover 0.016 thick for all valves, fittings, and flanges.
- E. Piping, Exposed:
 - 1. PVC, Color-Coded by System: 20 mils (0.5 mm) thick.
 - 2. Aluminum, Smooth or Stucco Embossed: 0.016 inch (0.41 mm) thick.
 - 3. Stainless Steel, Type 304 or Type 316, Smooth 2B Finish or Stucco Embossed: 0.010 inch (0.25 mm) thick.

3.21 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed:
 - 1. Aluminum, Stucco Embossed with Z-Shaped Locking Seam: 0.020 inch (0.51 mm) thick.

3.22 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230719

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 08 00 - 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. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

- A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- B. CxA: Commissioning Authority.
- C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

1.5 ALLOWANCES

- A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Section 012100 "Allowances."

1.6 UNIT PRICES

- A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Section 012200 "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.7 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meeting.
- C. Attend testing, adjusting, and balancing review and coordination meeting.
- D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.8 CxA'S RESPONSIBILITIES

- A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- B. Direct commissioning testing.
- C. Verify testing, adjusting, and balancing of Work are complete.
- D. Provide test data, inspection reports, and certificates in Systems Manual.

1.9 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
 - 2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
 - 4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
 - 5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
 - 6. Test and inspection reports and certificates.
 - 7. Corrective action documents.

8. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
 2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
- B. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- C. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- D. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

Malcolm X College- West Side Learning Center
Addition and Renovations

- E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION 230800

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23 - DIRECT DIGITAL CONTROL (DDC) SYSTEM 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. DDC system for monitoring and controlling of HVAC systems.

- B. Related Requirements:

- 1. Raceways:
 - a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
 - b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.

1.3 DEFINITIONS

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:
 - 1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
 - 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 - 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 - 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
 - 5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

- D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.
- F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- G. COV: Changes of value.
- H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.
- J. DOCSIS: Data-Over Cable Service Interface Specifications.
- K. E/P: Voltage to pneumatic.
- L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- M. HLC: Heavy load conditions.
- N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- O. I/P: Current to pneumatic.
- P. LAN: Local area network.
- Q. 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.
- R. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- S. Modbus TCP/IP: An open protocol for exchange of process data.
- T. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- U. MTBF: Mean time between failures.

- V. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
- W. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- X. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- Y. POT: Portable operator's terminal.
- Z. PUE: Performance usage effectiveness.
- AA. RAM: Random access memory.
- BB. RF: Radio frequency.
- CC. Router: Device connecting two or more networks at network layer.
- DD. Server: Computer used to maintain system configuration, historical and programming database.
- EE. TCP/IP: Transport control protocol/Internet protocol.
- FF. UPS: Uninterruptible power supply.
- GG. USB: Universal Serial Bus.
- HH. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- II. VAV: Variable air volume.
- JJ. WLED: White light emitting diode.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product include the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation, operation and maintenance instructions including factors effecting performance.
 - 5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
 - a. Workstations.
 - b. Servers.

- c. Printers.
 - d. Gateways.
 - e. Routers.
 - f. Protocol analyzers.
 - g. DDC controllers.
 - h. Enclosures.
 - i. Electrical power devices.
 - j. UPS units.
 - k. Accessories.
 - l. Instruments.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
 7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughput.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. Shop Drawings:

1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
2. Include plans, elevations, sections, and mounting details where applicable.

3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
6. Schematic drawings for each controlled HVAC system indicating the following:
 - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
 - a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.

- d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
- 9. DDC system electrical power riser diagram indicating the following:
 - a. Each point of connection to field power with requirements volts/ phase/ hertz/ amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/ phase/ hertz/ amperes/ connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.
- 10. Monitoring and control signal diagrams indicating the following:
 - a. Control signal cable and wiring between controllers and I/O.
 - b. Point-to-point schematic wiring diagrams for each product.
 - c. Control signal tubing to sensors, switches and transmitters.
 - d. Process signal tubing to sensors, switches and transmitters.
- 11. Color graphics indicating the following:
 - a. Itemized list of color graphic displays to be provided.
 - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
 - c. Intended operator access between related hierarchical display screens.
- D. System Description:
 - 1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
 - 2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
 - 3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure
 - h. Controller failure.
 - i. Instrument failure.
 - j. Control damper and valve actuator failure.
 - 4. Complete bibliography of documentation and media to be delivered to Owner.
 - 5. Description of testing plans and procedures.

6. Description of Owner training.

E. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Face velocity at Project design and minimum airflow conditions.
 - c. Pressure drop across damper at Project design and minimum airflow conditions.
 - d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
3. Schedule and design calculations for control valves and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Pressure-differential drop across valve at Project design flow condition.
 - c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
4. Schedule and design calculations for selecting flow instruments.
 - a. Instrument flow range.
 - b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
 - c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
 - d. Pressure-differential loss across instrument at Project design flow conditions.
 - e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Product installation location shown in relationship to room, duct, pipe and equipment.
 - b. Structural members to which products will be attached.
 - c. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices and other installed devices.
 - d. Size and location of wall access panels for products installed behind walls and requiring access.
2. Reflected ceiling 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:
 - a. Ceiling components.
 - b. Size and location of access panels for products installed above inaccessible ceiling assemblies and requiring access.
 - c. Items penetrating finished ceiling including the following:
 - 1) Lighting fixtures.
 - 2) Air outlets and inlets.
 - 3) Speakers.
 - 4) Sprinklers.
 - 5) Access panels.
 - 6) Motion sensors.
 - 7) Pressure sensors.
 - 8) Temperature sensors and other DDC control system instruments.

B. Qualification Data:

1. Systems Provider Qualification Data:
 - a. Resume of project manager assigned to Project.
 - b. Resumes of application engineering staff assigned to Project.
 - c. Resumes of installation and programming technicians assigned to Project.
 - d. Resumes of service technicians assigned to Project.
 - e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
 - f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
 - g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
 - h. Owner contact information for past project including name, phone number, and e-mail address.
 - i. Contractor contact information for past project including name, phone number, and e-mail address.
 - j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.
2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

- C. Welding certificates.
- D. Product Certificates:
 - 1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
- E. Preconstruction Test Reports: For each separate test performed.
- F. Source quality-control reports.
- G. Field quality-control reports.
- H. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For DDC system 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. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
 - j. List of recommended spare parts with part numbers and suppliers.
 - k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Include product manufacturers' recommended parts lists for proper product operation over four year period following warranty period. Parts list shall be indicated for each year.
- C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during one year period following warranty period.

1.8 QUALITY ASSURANCE

- A. DDC System Manufacturer Qualifications:
 - 1. Nationally recognized manufacturer of DDC systems and products.
 - 2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
 - 3. DDC systems and products that have been successfully tested and in use on at least five past projects.
 - 4. Having complete published catalog literature, installation, 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 DDC system installation training, commissioning and troubleshooting of installations.
 - e. Owner operator training.
- B. DDC System Provider Qualifications:
 - 1. Authorized representative of, and trained by, DDC system manufacturer.
 - 2. In-place facility located within 20 miles of Project.
 - 3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
 - 4. Demonstrated past experience on five projects of similar complexity, scope and value.
 - 5. Each person assigned to Project shall have demonstrated past experience.
 - 6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.

7. Service and maintenance staff assigned to support Project during warranty period.
 8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
 9. DDC 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. Testing Agency Qualifications: Member company of NETA.
1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- D. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
 4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."
- E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- F. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and products and for fabrication and installation.
1. Build mockups of completed installation where products are exposed to view and are located in areas with aesthetic requirements that warrant special attention, including the following spaces:
 2. Build mockups of completed installation for areas indicated on Drawings.
 3. Approval of mockups does not constitute approval of deviations from Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
- 1.9 PRECONSTRUCTION TESTING
- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on field mockups.
1. Include test assemblies representative of proposed materials and construction.
 2. Build mockup at testing agency facility using personnel, materials, and methods of construction that will be used at Project site.
 3. Notify Architect seven days in advance of dates and times of tests.
- B. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.
- 1.10 WARRANTY
- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.
 - a. For Gateway: Three year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

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

1. Trane
2. Distech
3. Automated Logic
4. Johnson Controls

1.1 BAS ARCHITECTURE/COMMUNICATION

- A. System Controller: The building automation system (BAS) shall consist of an HTML5 web-based System Controller or Controllers, communicating over the customer IP network to each other and to Operator Workstations via BACnet IP.
1. Each System Controller shall communicate to a network of Custom Application and Application Specific Controllers using BACnet MSTP as prescribed by the BACnet standard.
 2. Each System Controller shall function as a BACnet Router to all unit controllers providing all BACnet MSTP points as fully open and fully exposed, read/write capable, BACnet IP points to any higher level Enterprise BAS system or any 3rd party BACnet-capable BAS system.
 3. System Controllers and any required Servers or Server Software must be BTL Listed to ensure open protocol compatibility.
 4. Licensing. Provide all System Controllers and Servers with the following licensing, and all associated necessary hardware for each protocol, to ensure future compatibility and system expandability independent of the original installing contractor of the BAS:
 - a. BACnet MSTP (ASHRAE BACnet Standard, Data Link Layer – MS/TP Master Clause 9)
 - b. LonTalk (ASHRAE BACnet Standard, Data Link Layer – Clause 11)
 - c. BACnet IP (ASHRAE BACnet Standard, Data Link Layer - Annex J)

- d. BACnet/ZigBee (ASHRAE BACnet Standard, Data Link Layer - Annex O)
 - e. Modbus RTU
 - f. Modbus TCP/IP
- B. Custom Application and Application Specific Unit Controllers shall meet the following communication requirements:
 - 1. Communicate to System Controller via BACnet MSTP
 - 2. To allow maximum communications speed and co-existence with other controllers, the controller shall support at a minimum the following BACnet MSTP master baud rates: 9600, 19200, 38400, 76800, and 115200.
 - 3. To ensure compatibility to other BACnet systems the controller must be BTL Listed as:
 - a. Advance Applications Controller (B-AAC) for Custom Application Controllers
 - b. Application Specific Controller (B-ASC) and Supports sending alarm/event notifications to a subscriber, for Application Specific Controllers
- C. Wireless Custom Application and Application Specific Unit Controllers and Auxiliary Wireless Control devices shall conform to:
 - 1. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and signal range.
 - 2. Operating range shall be a minimum of 200 feet; open range shall be 2,500 ft. (762 m) with less than 2% packet error rate.
 - 3. Installation and replacement of failed sensors shall be accomplished automatically after power up of the failed device or power up of the properly addressed replacement device.
 - 4. Wireless communication shall be ASHRAE BACnet MSTP over ZigBee (Annex O).
 - 5. Wireless temperature, humidity and occupancy sensors shall be "maintenance-free" type and have a published battery life of no less than 15 years under typical operating range conditions as described above (10 years for wireless CO2 sensors).
 - 6. Wireless temperature, humidity, occupancy and CO2 sensors shall utilize IEEE 802.15.4 radios and shall be a part of the ZigBee mesh network.
 - 7. To ensure future compatibility to other BACnet systems each controller must be BTL Listed and ZigBee Building Automation (ZigBee-BA) certified.

1.2 OPERATOR INTERFACE

- A. The System Controller shall provide an embedded web-interface for end-user access to the building automation system (BAS). BAS web-interface shall be HTML5 to ensure universal browser compatibility includ-

ing PC's, laptop's, tablets and mobile phones. JAVA-based web-interfaces are not compatible with standard iOS and Android devices and are not acceptable.

- B. No dedicated PC workstation shall be required, as any current-version PC, laptop, tablet or mobile phone shall be capable of accessing the BAS. At a minimum the BAS web-interface shall be compatible with the following operating systems and browsers:
 - 1. Operating Systems:
 - a. Windows 7, Windows 8
 - b. MAC OS X 10.8 (Mountain Lion), 10.9 (Mavericks), 10.10 (Yosemite)
 - c. iOS (iPad/iPhone) V4.0+
 - d. Android (Tablet/Phone) V4.0+
 - 2. Web Browsers:
 - 1) Internet Explorer 8.0+
 - 2) Firefox 4.0+
 - 3) Chrome 10.0+
 - 4) Safari (iOS) V4.0+
 - 5) Android Chrome V4.0+
- C. Mobile Device Application ("App"): Provide to the owner as part of this project the corresponding mobile device and tablet application ("App") for the BAS System. All licensing and subscription costs for the application shall be included for 5 years and no fewer than five (5) individual licenses on both Android and Apple (iOS) devices. The Owner shall incur no cost to use the mobile device and tablet Application(s) for the 5 year period starting with Owner acceptance.
- D. Operator Displays: Provide color touchscreen operator displays for all Custom Application controllers including any central plant systems (HW, CHW, CW) and Air Handling Units (AHU's). Provide same animated BAS graphic viewable at the BAS for viewing on each operator display.

1.3 BAS SOFTWARE MINIMUM CAPABILITIES

- 1. System Security
 - a. Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
 - b. User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
 - c. Each operator shall be allowed to change their user password
 - d. The System Administrator shall be able to manage the security for all other users
 - e. User login/logoff attempts shall be recorded.
 - f. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
- 2. On-Line Help and Training

- a. Provide a context sensitive, on-line help system to assist the operator in operation and configuration of the system.
 - b. Provide on-line owner training videos for typical daily operator tasks
3. Equipment Graphics: HVAC equipment graphics shall be 3D photo-realistic animated type with animated fans, dampers and coils. Links shall be available from each graphic page to view all equipment data points, setpoints and equipment trend logs.
4. System Graphics: HVAC systems shall have custom 3D flow-based animated graphics created and loaded into the BAS for each system, including HW, CHW and Condenser water systems. Links shall be available from each graphic page to view all system data points, setpoints and system trend logs.
5. Manual Control and Override.
 - a. Point Control: Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
 - b. Temporary (Expiring) Overrides: The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
 - c. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
 - d. Provide an "All Points In Override" report at the BAS Reports menu to allow the end user to easily identify all of the overrides that exist in the system.
6. Scheduling. An everyday user shall be able to perform the following tasks at the BAS:
 - a. Create a new schedule, defining the default values, events and membership.
 - b. Create exceptions to a schedule for any given day.
 - c. Apply an exception that spans a single day or multiple days.
 - d. View a schedule by day, week and month.
 - e. Exception schedules and holidays shall be shown clearly on the calendar.
 - f. Modify the schedule events, members and exceptions.
 - g. Create Optimal Start/Stop schedules, define an early start limit, utilize outdoor air temperature compensation, and show current active heating and cooling rates (min/deg).
7. Trend Logs
 - a. Trend Log Creation. The daily user shall be able to create and define a trend log for any point available in the BAS.
 - b. Trend Log Viewing.
 - 1) The operator interface shall allow Trend Log data to be viewed in a tabular or graphical format, printed, and exported to a PDF or Excel file at a minimum.
 - 2) Trend log viewing including the capability to show a minimum of 5 points on a chart with each displayed in a unique color and with data values shown upon mouse-over.
 - c. Trend Log Capacity. Provide a minimum capacity of 3 years of trend data storage at 15-minute sampling interval for a minimum of 10 points per controller in the system.
 - d. Trend Log Setup. BAS contractor shall setup at a minimum 90-days of trend logs sampled at 15 minute interval for every Space Temperature and Space Setpoint value in the system.

8. Alarm/Event Notification
 - a. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
 - b. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.
 - 1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - 2) Alarm/Event Log shall be capable of storing the last 1000 alarms/events indefinitely
 - 3) An operator with the proper security level may acknowledge and clear alarms/events.
 - 4) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
 - c. Email Alarming. Alarms shall be capable of being emailed out to various recipients at varying severity levels, along with cascading email alarms when critical alarms are not acknowledged in a timely manner.
 - d. Alarm Scheduling. Alarms shall be schedulable so as to be sent to different recipients/locations based on the time of day and the day of the week.
9. Reports
 - a. The BAS shall allow a user to export reports in PDF or Excel formats at a minimum.
 - b. Define and provide the following points to all users of the BAS:
 - 1) All Points in Alarm Report: Provide an on demand report showing all current alarms.
 - 2) All Points in Override Report: Provide an on demand report showing all overrides.
 - 3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - 4) All Points Report: Provide a report that lists the current value of all points
10. Standard BAS Routines and Programming
 - a. VAV System Coordination. Provide programming necessary to ensure equipment safety and minimize energy usage, including:
 - 1) Startup and shutdown the air handler safely. Ensure the VAV boxes are open sufficiently when the equipment is running, to prevent damage to the ductwork and VAV boxes due to high air pressure.
 - 2) Ensure minimum air flows for gas and electric heating applications.
 - 3) Automatically scheduled calibration of the VAV boxes.
 - 4) Static Pressure Optimization Routine (Per ASHRAE 90.1-2013)
 - 5) Area-Based Scheduling Control. Provide multiple time of day schedules for each Area of VAV zones with different scheduling needs and shut unoccupied VAV box dampers to provide fan horsepower energy savings.
 - 6) Timed Override. Provide functionality and programming to allow building occupants to override the VAV system to the occupied mode for a user-definable time period.
 - 7) Changeover-Bypass System Zone Voting Logic. Provide Changeover zone voting logic with heat/cool callers, strong heat/cool callers and voting enabled/disabled functionality to control individual zones in RTU/AHU changeover systems with static pressure controlled bypass dampers.

11. Custom 3D Floorplan Graphics

- a. Contractor shall create and provide or shall consult a graphics design contractor (e.g. QA Graphics, www.qagraphics.com) and provide custom 3D floorplan graphics with extruded 3D walls, showing supply ductwork and showing terminal equipment locations.
- b. Active space temperature sensor readings shall be shown on each 3D floorplan graphic in the approximate location of the space temperature sensor.
- c. Provide no more than 15 devices/controllers/space sensors per 3D graphic page. Provide additional graphic pages partitioned as necessary to maintain 15 or less devices/controllers/space sensors per 3D graphic page.
- d. Provide overall mini-map graphic on each floorplan graphic page showing building partitions and provide hyperlinks to each individual graphic page from the mini-map.
- e. Provide hyperlinks on all equipment and temperature readings linking directly to the equipment graphic page.

1.4 ACCEPTABLE MANUFACTURERS AND INSTALLING CONTRACTORS

- A. Trane
- B. Automated Logic
- C. Johnson Controls

1.5 SYSTEM CONTROLLERS

- A. There shall be one or more independent microprocessor-based System Controllers to contain and provide the BAS Software Minimum Capabilities as previously described.
 1. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 2. The controller shall provide a USB communications port for direct connection to a PC or laptop.
 3. All System Controllers shall have a real time clock.
 4. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller shall be mounted in a NEMA-1 enclosure at a minimum, and shall be rated for operation at -40°C to 50°C [-40°F to 122°F].
 5. Clock Synchronization.
 - a. All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
 - b. All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
 - c. All System Controllers shall automatically adjust for daylight savings time if applicable.

6. Serviceability

- a. Provide diagnostic LEDs for power, communications, and processor.
 - b. The System Controller shall have an LED display on the main board that indicates the current operating mode of the controller.
7. Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System Controller
8. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage
9. BACnet Testing Labs (BTL) Listing. Each System Controller shall be listed as a BACnet Building Controller (B-BC) by BACnet Testing Labs.

1.6 CUSTOM APPLICATION CONTROLLERS

- A. Description. Custom Application Controllers are controllers that operate Applied Air-handling Units (AHU's), Central Chilled Water, Condenser Water, Steam and Hot Water Systems and are fully programmable for each application, per the sequence of operation.
- B. Custom Application Controller Hardware and Software Requirements
1. Scheduling. The Controller shall have a built in schedule using a Real Time Clock with a 7 day power backup and shall be capable of operating standalone from its local operator display
 2. Trend Logs. For ease of troubleshooting, the Controller shall support data trend logging
 - a. Trends shall be capable of being collected at a minimum sample rate of once every second with a minimum total capacity of 25,000 samples.
 - b. Trends shall be capable of being viewed from the BAS or the local operator display
 3. Licensing. Controllers with individual licenses available from the manufacturer, with varying degrees of features available to the owner, shall be provided with the license providing the most feature-rich controller. Licensing that restricts the feature set available to the owner shall not be acceptable.
 4. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.
 - a. Storage conditions:
 - 1) Temperature: -67°F to 203°F (-55°C to 95°C)
 - 2) Humidity: Between 5% to 100% RH (non-condensing)

- b. Operating conditions:
 - 1) Temperature: -40°F to 158°F (-40°C to 70°C)
 - 2) Humidity: Between 5% to 100% RH (non-condensing)
- c. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum
- d. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40°F to 158°F [-40°C to 70°C].
- 5. Inputs/Outputs: The Controller shall have on-board or expansion I/O capable of performing all functionality needed for the application, including:
 - a. Shall support flexibility in actuator type, the controllers shall be capable of supporting the following actuator control types 0-10VDC, 0-5VDC, 4-20mA, 24VAC - 2 position.
 - b. Shall support flexibility in sensor type, the Controller shall be of reading sensor input ranges of 0 to 10V, 0 to 20mA, 50ms or longer pulses, 200 to 20Kohm and RTD input.
 - c. Shall support flexibility in sensor type, the Controller and/or expansion modules shall support dry and wetted (24VAC) binary inputs.
 - d. The controller support pulse accumulator for connecting devices like energy meters.
 - e. In order to support a wide range of devices, the Controller's binary output shall be able to drive at least 10VA each.
 - f. Spare I/O. Any Spare I/O that is unused by functionality needed for the equipment shall be available to be used by custom programming on the Controller and by the BAS.
 - g. The Controller shall provide 24VAC and 24VDC power terminals.
 - h. Controller shall be capable of expanding to at least 100 hardware I/O terminations.
- 6. Serviceability – The Controller shall provide the following to improve serviceability.
 - a. Diagnostic LEDs for power/normal operation/status, BACnet communications, sensor bus communications, and binary outputs. All wiring connections shall be clearly labeled and made to be field removable.
 - b. Software service tool connection through all of the following methods: direct USB cable connection to the Controller, USB connection through another controller on the BACnet link and through USB connection to the System Controller.

- c. Programming and testing of controller programs must, for safety purposes, be initially able to be accomplished with the power off to the equipment and to the controller.
 - d. Capabilities to temporarily override the BACnet point values with time-expiring overrides.
- 7. Software Retention: All Controller operating parameters, setpoints, BIOS, and sequence of operation code must be stored in non-volatile memory in order to maintain such information for months without power.
- 8. Controller must meet the following Agency Compliance:
 - a. UL916 PAZX, Open Energy Management Equipment
 - b. UL94-5V, Flammability
 - c. FCC Part 15, Subpart B, Class B Limit
 - d. BACnet Testing Laboratory (BTL) Listed
 - e. cUL and CE Marked for international compliance
- C. Local Operator Interface: A local Color Touchscreen Operator Display shall be provided for all Custom Application Controllers. The operator interface shall enable the user to view and edit data. A system security password shall be available to prevent unauthorized use of the keypad and display. Local operator display shall meet the minimum specification as listed below:
 - 1. Point Overrides. Override any hardwired output point to any value within its range.
 - 2. Graphics. Display same graphic as displayed at the BAS page for the equipment/system.
 - 3. Editable time of day schedule (with exception creating ability) for standalone applications.
 - 4. Optional User Security (Ability to setup user security for making changes and overrides).
 - 5. Trend Logs. User shall be able to view graphical trend logs for the equipment under control.
 - 6. Operating Conditions:
 - 1) Temperature: -40°F to 158°F (-40°C to 70°C)
 - 2) Humidity: Between 5% to 100% (non-condensing)
 - 7. Environmental rating (enclosure): IP56 (dust and strong water jet protected)
 - 8. Tracer TD7 operator display, Kele BBC-SD operator display, or approved equal

1.7 APPLICATION SPECIFIC CONTROLLERS

- A. Description. Application Specific Controllers (ASC) shall be microprocessor-based DDC controllers which through hardware and firmware design control specified equipment. They are not typically user-programmed, but are configurable for operation within the confines of the equipment they are designed to serve (e.g. VAV's, Fan Coils, Cabinet Unit Heaters, Blower Coils, Unit Ventilators, Heat Pumps, Chilled Beams, and Water Source Heat Pumps).
- B. Application Specific Controller Hardware and Software Requirements.
 - 1. Enclosures. All Application Specific Controllers not installed within the equipment being controlled shall be provided with and installed in a NEMA-1 rated metal enclosure at a minimum. All VAV controllers

and VAV damper actuators shall be installed in and protected from dirt and dust by a NEMA-1 metal enclosure.

2. Software. To meet the sequence of operation for each equipment type the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or field-downloaded with a service tool into the controller. Controller shall be capable of being fully field programmed to accomplish custom sequences of operation and/or utilize Spare I/O.
3. Licensing. Controllers with individual licenses available from the manufacturer, with varying degrees of features available to the owner, shall be provided with the license providing the most feature-rich controller. Licensing that restricts the feature set available to the owner shall not be acceptable.
4. Stand-Alone Operation: Each piece of equipment shall be controlled by a single DDC controller and provide stand-alone control in the event of a communications failure, utilizing last known communicated values and/or comm-fail values.
5. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.
 - a. Storage: -55 to 203°F (-48 to 95°C) and 5 to 95% RH (non-condensing).
 - b. Operating: -40 to 158°F (-40 to 70°C) and 5 to 95% RH (non-condensing).
 - c. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum
 - d. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40°F to 158°F [-40°C to 70°C].
6. Inputs/Outputs:
 - a. For flexibility in selection and replacement of valves, the controllers shall be capable of supporting all of the following valve control types 0-10VDC, 0-5VDC, 4-20mA, 24VAC floating point, 24VAC - 2 position (Normally or Normally Closed).
 - b. For flexibility in selection and replacement of sensors, the controllers shall be capable of reading sensor input ranges of 0 to 10V, 0 to 20mA, pulse counts, and 200 to 20Kohm.
 - c. For flexibility in selection and replacement of binary sensors, the controller shall support dry and wetted (24VAC) binary inputs.
 - d. For flexibility in selection and replacement devices, the controller's shall have binary output which are able to drive at least 12VA each.
 - e. For flexibility in selection and replacement of motors, the controller shall be capable of outputting 24VAC (binary output), DC voltage (0 to 10VDC minimum range) and PWM (in the 80 to 100 Hz range).
 - f. Spare I/O. Any Spare I/O that is unused by functionality needed for the equipment shall be available to be used by custom programming on the Controller and by the BAS.
 - g. Expandability. For future expandability needs controller shall be capable of expanding to at least 50 hardware I/O terminations.
7. Serviceability – The controller shall provide the following to improve serviceability.

- a. Diagnostic LEDs shall indicate correct operation or failures/faults for all of the following: power, sensors, BACnet communications, and I/O communications bus.
 - b. All binary output shall have LED's indicating the output state.
 - c. Software service tool connection through all of the following methods: direct USB cable connection to the Controller, USB connection through another controller on the BACnet link and through USB connection to the System Controller.
 - d. For safety purposes, the controller shall be capable of being powered by a portable computer USB cable for the purposes of configuration, programming, and testing programs so that this work can be accomplished with the power off to the equipment.
 - e. Capabilities to temporarily override BACnet point values with expiring overrides.
 - f. BACnet trending objects resident on controller
 - 1) Shall be capable of trending all BACnet points used by controller
 - 2) Minimum of 20,000 trending points total on controller
 - 3) Shall be capable of 1 second sample rates on all points
8. Software Retention: All Zone Controller operating parameters, setpoints, BIOS, and sequence of operation code must be stored in non-volatile memory in order to maintain such information for months without power.
9. Agency Approval: The controller shall have met the following Agency Compliance:
- a. UL916 PAZX, Open Energy Management Equipment
 - b. UL94-5V, Flammability
 - c. FCC Part 15, Subpart B, Class B Limit
 - d. BACnet Testing Laboratory (BTL) Listed
 - e. cUL and CE Marked for international compliance

PART 3 - EXECUTION

1.1 COORDINATION

A. Test and Balance

1. The contractor shall furnish 4 (Four) sets of all software and hardware tools necessary to interface to the control system and each individual unit controller for test and balance purposes.
2. The contractor shall provide training in the use of these tools. In addition, the contractor shall provide a qualified controls programmer to assist in the test and balance process for a minimum duration of 8 hours.

B. Life Safety

1. Duct smoke detectors required for air handler shutdown shall be supplied and installed under Section 230000 of this specification. Duct smoke detector wiring for unit shutdown shall be supplied under Section 260000. The mechanical and electrical contractors shall coordinate interlock of smoke detectors to air handlers for shutdown as described in the Sequences of Operation for this project.

1.2 GENERAL WORKMANSHIP

- A. Install equipment, piping, wiring/conduit, parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible locations as defined by National Electric Code (NEC). Control panels shall be attached to structural walls or properly supported in a free-standing configuration, unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
- D. Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures.
- E. All control device installation and wiring shall comply with Contract Documents, acceptable industry specifications, and industry standards for performance, reliability, and compatibility. Installation and wiring shall be executed in strict adherence to local codes and standard practices referenced in Contract Documents.

1.3 FIELD QUALITY CONTROL

- A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Contract Documents.
- B. BAS manufacturer shall continually monitor the field installation for building code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.
- C. BAS installing Contractor(s) shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

1.4 WIRING

- A. All control and interlock wiring shall comply with the National, Local Electrical Codes, and Section 260000 of these Contract Document specifications. Where the requirements of this section differ with those in Section 260000, the requirements of this section shall take precedence.

- B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC requirements.
- C. Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used provided that the following conditions are met:
- D. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
- E. All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose).
- F. Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.
- G. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m (10 ft.) intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 1.5 m (5 ft.) intervals or more often to achieve a neat and workmanlike result.
- H. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- I. Maximum allowable voltage for control wiring shall be 120Vac. If only higher voltages are available for use, the BAS manufacturer shall provide step-down transformers to achieve the desired control voltages.
- J. All control wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
- K. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.
- L. Conduit and wire sizing shall be determined by the BAS manufacturer in order to maintain manufacturer's recommendation and meet National and Local Codes.
- M. Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.
- N. Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.

- O. BAS manufacturer shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- P. Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

1.5 COMMUNICATION WIRING

- A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- B. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer shall not be exceeded during installation.
- D. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
- E. When a cable enters or exits a building, a lighting arrestor must be installed between the line and ground.
- F. All runs of communication wiring shall be unspliced length when the length is commercially available.
- G. All communication wiring shall be labeled to indicate origin and destination.

1.6 INSTALLATION OF SENSORS

- A. Sensors required for mechanical equipment operation shall be factory installed and wired as specified in mechanical equipment specifications. BAS manufacturer shall be responsible for coordinating these control devices and ensuring the sequence of operations will be met. Installation and wiring shall be in accordance with the BAS manufacturer's recommendations.
- B. Sensors that require field mounting shall meet the BAS manufacturer's recommendations and be coordinated with the mechanical equipment they will be associated.

- C. Mount sensors rigidly and adequately for the environment the sensor will operate.
- D. Wired room temperature sensors shall be installed on concealed junction boxes properly supported by the block wall framing. For installation in dry wall ceilings, the low voltage sensor wiring can be installed exposed and must meet applicable National and Local Electrical Codes.
- E. All wires attached to wall mounted sensors shall be sealed off to prevent air from transmitting in the associated conduit and affecting the room sensor readings.
- F. Install duct static pressure tap with tube end facing directly down-stream of air flow.
- G. Install space static pressure sensor with static sensing probe applicable for space installation where applicable.
- H. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
- I. All pipe mounted temperature sensors shall be installed in matched thermowells. Install all liquid temperature sensors with heat conducting fluid in thermal wells for adequate thermal conductance.
- J. Wiring for space sensors shall be concealed in building drywall. EMT conduit is acceptable within mechanical equipment and service rooms.
- K. Install central plant outdoor air temperature sensor on north wall complete with sun shield at manufacturer's recommended location and coordinated with Engineer.

1.7 IDENTIFICATION OF HARDWARE AND WIRING

- A. All field wiring and cabling, including that within factory mounted, and wired control panels and devices for mechanical equipment, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information for troubleshooting, maintenance, and service purposes. BAS manufacturer to coordinate this labeling requirement with mechanical equipment manufacturer as it relates to controls.
- B. Permanently label or code each point of field terminal strips to show the instrument or item served and correlate them to the BAS design drawings.
- C. Identify control panels with minimum 1-cm letters on laminated plastic nameplates.
- D. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

1.8 CONTROL SYSTEM CHECKOUT AND TESTING

- A. Start-up testing. All testing in this section shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all of the instruments, controls, and accessory equipment furnished under this specification.
 2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturer's recommendations.
 4. Verify all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starter, etc.) operate properly and normal positions are correct.
 5. Verify all analog output devices (I/Ps, actuators, etc) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 6. Verify the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimal start/stop routines.
 7. Alarms and Interlocks
 - a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

1.9 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- A. Demonstration: A complete demonstration of the capabilities of the BAS system shall be performed by the BAS manufacturer's field personnel. The BAS manufacturer shall dedicate a minimum of (16) hours on-site with the Owner representatives, and Engineer to demonstrate a complete functional test of all the BAS system requirements. This BAS demonstration shall constitute an acceptance inspection, and will represent the process of approving the BAS as designed and specified. Functional testing shall include, but is not limited to, the following system level components where installed:
 - 1. Variable Air Volume Systems
 - a. Ventilation Reset
 - 1) Demonstrate system level operation including 15 minute interval trend report of ventilation optimization air setpoint and outdoor air flow (cfm) over one week period. Deliver trend report to Owner representatives and Engineer.
 - 2) Dynamically show maximum ventilation ratio source VAV on user interface.
 - b. Fan Pressure Optimization
 - 1) Demonstrate system level operation including 15 minute interval trend report of duct static optimization duct static pressure setpoint and duct static pressure over one week period. Deliver trend report to Owner representatives and Engineer.
 - 2) Dynamically show maximum VAV damper position source on user interface.
- B. Acceptance: The BAS will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.

1.10 CLEANING

- A. Provide The BAS manufacturer's installing contractor(s) shall clean up all debris resulting from their installation activities on a daily basis. The installation contractors shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Owner, Construction Manager, General Contractor, and/or Mechanical Contractor.
- B. At the completion of work in any area, the installation contractor shall clean all of their work, equipment, etc., making it free from dust, dirt and debris.
- C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage. Any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

1.11 TRAINING

- A. Provide minimum of (4) classroom training sessions, and (4) hours for each session, throughout the contract period. The training will be provided for personnel designated by the Owner.
- B. These objectives will be divided into logical groupings; participants may attend one or more of these, depending on level of knowledge required:
 - 1. Day-to-day BAS Operators
 - 2. BAS Troubleshooting & Maintenance
- C. The instructor(s) shall be a controls system programmer, shall be factory-trained and shall be experienced in teaching this technical material.

1.12 WARRANTY REQUIREMENTS

- A. Warrant all work as follows:

1. BAS, system controller(s), unit controllers, control devices, sensors, installation and wiring labor and all materials shall be warranted free from defects for a period of twenty-four (24) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner (Parts and Labor warranty must be provided to the owner by the BAS manufacturer). The BAS manufacturer shall respond to the Owner's request for warranty service within 24 hours of the initiated call and will occur during normal business hours (8AM-5PM).
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BAS is operational, and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
3. BAS system controller software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by the Owner must be granted prior to the installation of these updates.
4. The BAS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, user tips and training schedules for a two year period of time correlating with the warranty period.

1.13 ACTIVE MONITORING SERVICE

A. Description

1. Continuously monitors building systems, generates equipment level faults and alarms, and professional analysis to either resolve issues remotely or direct necessary on-site services, provided by this contractor for the duration of the warranty period.

B. Remote Monitoring Center Requirements

1. Remote Monitoring Center infrastructure and staff shall provide alarm detection and professional analysis, leading to alarm resolution or diagnostic details relayed to onsite personnel.
2. Shall be available 24 hours/day, 7 days/week , 365 days per year.
3. Shall have full redundancy in systems at the data center level to fully support a 24/7/365 operation. This includes, but is not limited to, the following systems: electrical, phone, database, and support.

4. Shall have a staff of controls specialists who have relevant field experience in HVAC applied systems operations.
5. In the event of an outage at the primary remote center, a redundant site shall be in place to provide additional backup and support.
6. To ensure quality standards, the center shall have shift supervisors available for any escalated measures 24/7/365.

C. Mandatory Service Requirements

1. Shall design and set-up specified alarms per site/owner specific requirements.
2. Shall detect failures in building systems and procedures including, but not limited to:
 - a. Monitoring energy use, overrides, equipment performance or other variables deviate from desired parameters.
 - b. Space comfort monitoring service shall generate alarms indicating temperatures have risen above acceptable norms in your facility.
3. Shall include monitoring by experienced HVAC professionals to analyze what each alarm means, resolve issues quickly and or initiate on-site actions to resolve the issue.
4. Shall support on-site technical services by identifying the necessary parts and equipment to resolve detected faults.

D. Active Monitoring Response Requirements and Tests

1. Alarms: Upon receipt of an alarm, a technical specialist from the Remote Monitoring Center shall diagnose the issue and troubleshoot in an attempt to correct the problem without initiating any on-site requirement.
2. Dispatch: If correcting the alarm remotely is not possible, the Remote Monitoring Center shall dispatch a service technician with information about the issue and provide recommendations to correct the problem in the field.
3. Phone Support: Service provider shall use telephone support to dispatch a service technician, and ensuring that only the most appropriate owner contacts, technicians, and field support personnel are involved. This allows for smarter and more efficient service that ensures accurate calls in cases where this type of maintenance is required.

Malcolm X College- West Side Learning Center
Addition and Renovations

4. Remote Monitoring Center shall compile and store a history of all critical alarms and actions associated with it.
5. Start-up test: During start-up and commissioning of alarm reporting, service provider may trip alarms to demonstrate remote capability.
1. Communications Test: Service Provider shall routinely test the communication link between the remote monitoring center and provide a record of this test.

END OF SECTION 230923

SECTION 23 09 23.16 - GAS INSTRUMENTS

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 Gas Instruments:
 - 1. Carbon-dioxide sensors and transmitters.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

- A. NDIR: Nondispersive infrared.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Installation instructions, including factor affecting performance.
 - 3. Product description with complete technical data, performance curves, product specification sheets.
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.
 - 2. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other,

showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

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

1. Vaisala.
2. Veris Industries.
3. Trane

- B. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

- C. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

- D. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

- E. Provide calibration kit. Turn over to Owner at start of warranty period.

- F. Enclosure: Lexan.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates 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 instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.
- D. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRICAL POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.

- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification on face.

3.6 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.

- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record videos on DVD disks.
- D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.16

SECTION 23 09 23.19 - MOISTURE INSTRUMENTS

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 moisture switches, sensors, and transmitters.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Product description with complete technical data, performance curves, and product specification sheets.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MOISTURE SENSORS AND TRANSMITTERS

- A. Combination Humidity and Temperature Sensor and Transmitter with Display:
 - 1. Description:
 - a. Factory package consisting of humidity and temperature sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.

- b. Each transmitter shall be individually calibrated and provided with NIST traceable calibration certifications.
 - c. Provide a service cable for connecting to a notebook computer and Microsoft Windows compatible software.
- 2. Display:
 - a. Alphanumeric display of the following on the face of the enclosure:
 - 1) Percent relative humidity.
 - 2) Dry-bulb temperature.
 - 3) Wet-bulb temperature.
 - 4) Dew point temperature.
 - 5) Enthalpy.
 - b. Visual display of measurement trends, and minimum and maximum values over a one-year period.
- 3. Electronics Enclosure:
 - a. Integral to sensors for wall- (room-)mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
 - b. NEMA 250, Type 4 or 4X.
 - c. Labeled terminal strip for field wiring connections.
- 4. Programming:
 - a. Transmitter parameters shall be field programmable through keypad on the face of the enclosure.
 - b. Programmed parameters shall be stored in nonvolatile EEPROM.
- 5. Output Signals:
 - a. Three Analog Outputs: 4 to 20 mA or zero to 10-V dc for each output.
- 6. Temperature Sensor:
 - a. Temperature range matched to application, but not less than minus 40 to 140 deg F (minus 40 to 60 deg C).
 - b. Within 0.5 deg F (0.3 deg C) accuracy over the temperature range of 50 to 100 deg F (10 to 38 deg C) and within 1 deg F (0.6 deg C) over the remainder of the range.
 - c. Provide duct installation kit for duct applications.
- 7. Humidity Sensor:
 - a. Relative Humidity Measurement Range: Zero to 100 percent.
 - b. Response time in still air within 40 seconds.
 - c. Accuracy including non-linearity, hysteresis, and repeatability:
 - 1) For Temperature Between 59 and 77 Deg F (15 to 25 Deg C) and Relative Humidity between Zero and 90 Percent: Within 1 percent.

- 2) For Temperature between 59 and 77 Deg F (15 to 25 Deg C) and Relative Humidity between 90 and 100 Percent: Within 1.7 percent.
 - 3) For Temperature between Minus 4 and 104 Deg F (Minus 20 to 40 Deg C): Within 1 percent plus 0.008 times relative humidity reading.
 - 4) For Temperature between Minus 40 and 356 Deg F (Minus 40 to 180 Deg C): Within 1.5 percent plus 0.015 times the relative humidity reading.
- d. Sintered, stainless-steel filter, protecting sensor.
 - e. Provide duct installation kit for duct applications.
8. Power Supply:
- a. Field Power: 120-V ac, 60 Hz unless otherwise required by the application.
 - b. Internal Power: As required by transmitter.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOISTURE INSTRUMENT APPLICATIONS

- A. Combination humidity and temperature sensor and transmitter with display.

3.3 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, wiring, and conduit to comply with requirements indicated.
- C. Fastening Hardware:
 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 MOISTURE INSTRUMENTS INSTALLATION

- A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
- B. Mounting Height:
 - 1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
 - 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches (1.5 m).

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection.

- B. Install engraved phenolic nameplate with instrument identification on face of ceiling directly below instruments concealed above ceilings.

3.7 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.
 - 6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
 - 7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - 8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.
- C. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact.
- D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.9 MAINTENANCE SERVICE

- A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of systems and equipment Installer. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record videos on DVD disks.
- D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.19

SECTION 23 09 23.21 - MOTION INSTRUMENTS

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. PIR motion sensors.
- 2. Ultrasonic motion sensors.
- 3. Dual-technology motion sensors.

- B. Related Requirements:

- 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

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

- 1. Include operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
- 2. Include product description with complete technical data, performance curves, and product specification sheets.

- B. Shop Drawings:

- 1. Include details of product 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.
- 3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation 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. Product installation location shown in relationship to visual range and obstructions.
2. Wall- and ceiling-mounted instruments located in finished space showing relationship to other installed devices.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For motion instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 INDOOR MOTION SENSORS

- A. Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn on when covered area is occupied and off when unoccupied; with a time delay for turning off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A load at 120- and 277-V ac. Power supply to sensor shall be 24-V dc, 150 mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knock out in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: Digital display, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
- B. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in coverage area.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.
- C. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in coverage area.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).
- D. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in coverage area. A particular technology or combination of technologies that controls on-off functions shall be field selectable by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling. Apply occupancy detectors where indicated.

2.2 SWITCHBOX-MOUNTED MOTION SENSORS

- A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (zero to 49 deg C).
 3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B. Coordinate layout and installation of wall-mounted devices with other wall-mounted devices. Align centerline with adjacent devices. Align centerline with devices above.
- 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 ELECTRICAL POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and 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. 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.
- D. Motion instruments will be considered defective if they do not pass tests and inspections.

- E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. Verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.7 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for direct-digital control systems specified in Section 230923 "Direct-Digital Control System for HVAC."
- B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 230923.21

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 09 23.23 - PRESSURE INSTRUMENTS

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. Air-pressure sensors.
 - 2. Air-pressure transmitters.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

- A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation instructions, including factors affecting performance.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation 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. Product installation location shown in relationship to room, duct, pipe, and equipment.
 2. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
 3. Size and location of wall access panels for instruments installed behind walls.
 4. Size and location of ceiling access panels for instruments installed in accessible ceilings.
- B. Product Certificates: For each product requiring a certificate.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Environmental Conditions:
 1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.
 2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument-installed location shall dictate following NEMA 250 enclosure requirements:
 - a. Indoors, Heated and Air-Conditioned: Type 1.
 - b. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.

2.2 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:

1. Insertion length shall be at [4 inches (100 mm)] [6 inches (150 mm)] [8 inches (200 mm)] [12 inches (300 mm)].
2. Sensor with four radial holes of 0.04-inch (1-mm) diameter.
3. [Brass] [or] [stainless-steel] construction.
4. Sensor with threaded end support, sealing washers and nuts.
5. Connection: NPS 1/4 (DN 6) compression fitting.
6. Suitable for flat oval, rectangular, and round duct configurations.

B. Duct Insertion Static Pressure Sensor:

1. Sensor probe with two opposing orifices designed to reduce error-associated air velocity.
2. Sensor insertion length shall be [4 inches (100 mm)] [or] [8 inches (200 mm)].
3. Construct sensor of [6061-T6 aluminum alloy] [or] [Type 304 stainless steel].
4. Connection: Threaded, NPS 1/8 (DN 6) swivel fitting for connection to copper tubing or NPS 1/4 (DN 10) barbed fitting for connection to polyethylene tubing.
5. Sensor probe attached to a mounting flange with neoprene gasket and two holes for fasteners.
6. Mounting flange shall suitable for flat oval, rectangular, and round duct configurations.
7. Pressure Rating: 10 psig (69 kPa).

C. Duct Traverse Static Pressure Sensor:

1. Sensor shall traverse the duct cross section and have at least one pickup point every 6 inches (150mm) along length of sensor.
2. Construct sensor of 18-gage Type T6063-T5 extruded and anodized aluminum.
3. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
4. Mounting plate with threaded, NPS 3/8 (DN 12) compression fitting for connection to tubing.
5. Accuracy within 1 percent of actual operating static pressure.
6. Dual offset static sensor design shall provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30 degree yaw and pitch.
7. Suitable for velocities of 100 to 10000 fpm (0.51 to 51 m/s) and temperatures of up to 200 deg F (93 deg C).
8. Sensor air resistance shall be less than 0.1 times the velocity pressure at probe-operating velocity.
9. Suitable for flat oval, rectangular, and round duct configurations.

D. Outdoor Static Pressure Sensor:

1. Provides average outdoor pressure signal.
2. Sensor with no moving parts.
3. Kit includes sensor, vinyl tubing mounting hardware.

E. Space Static Pressure Sensor for Exposed or Suspended Mounting:

1. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm (5.1 m/s) from a 360-degree radial source.
2. [Aluminum] [Stainless steel] with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.

3. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
4. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
5. Surface-mounted sensor with 0.125-inch (3-mm) fitting for exposed tubing connection.
6. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
7. Suspended sensor with NPS 1/2 (DN 15) fitting for exposed pipe or tubing connection.

2.3 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy: Within [1] percent of the full-scale range.
 - c. Hysteresis: Within 0.10 percent of full scale.
 - d. Repeatability: Within 0.05 percent of full scale.
 - e. Stability: Within 1 percent of span per year.
 - f. Overpressure: 10 psig (69 kPa).
 - g. Temperature Limits: Zero to 150 deg F (Minus 18 to 66 deg C).
 - h. Compensate Temperature Limits: 40 to 150 deg F (4 to 66 deg C).
 - i. Thermal Effects: 0.033 percent of full scale per degree F.
 - j. Shock and vibration shall not harm the transmitter.
2. Output Signals:
 - a. Analog Current Signal:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 800-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to 10 V.
 - 2) Minimum Load Resistance: 1000 ohms.
3. Display: Four-digit digital display with minimum 0.4-inch- (10-mm-) high numeric characters.
4. Operator Interface: Zero and span adjustments located behind cover.
5. Construction:
 - a. Plastic casing with removable plastic cover.
 - b. Threaded, NPS 1/4 (DN 10) swivel fittings for connection to copper tubing or NPS 3/16 (DN 7) barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
 - c. Screw terminal block for wire connections.
 - d. Vertical plane mounting.
 - e. NEMA 250, Type 4.
 - f. Provide mounting bracket suitable for installation.

B. Air-Pressure Differential Indicating Transmitter:

1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F (25 deg C).
 - c. Stability: Within 1 percent of full scale per year.
 - d. Overpressure: 10 psig (69 kPa).
 - e. Temperature Limits: 20 to 120 deg F (Minus 7 to 49 deg C).
 - f. Thermal Effects: 0.055 percent of full scale per degree F.
2. Display: Four-digit digital display with minimum 0.4-inch- (10-mm-)high numeric characters.
3. Operator Interface:
 - a. Zero and span adjustments.
 - b. Selectable engineering units.
4. Analog Output Current Signal:
 - a. Two-wire, 4- to 20-mA dc current source.
 - b. Signal capable of operating into a 1200-ohm load.
5. Construction:
 - a. Plastic casing with clear plastic cover.
 - b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
 - c. Terminal block for wire connections.
 - d. Vertical plane mounting.
 - e. NEMA 250, Type 1.
 - f. Nominal 4-inch (100-mm) diameter face.
 - g. Mounting Bracket: Appropriate for installation.

C. Air-Pressure Differential Indicating Transmitter:

1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy including hysteresis and repeatability: Within 0.25 percent of full scale.
 - c. Stability: Within 1 percent of full scale per year.
 - d. Overpressure: Varies with range. At least 1.5 times range.
 - e. Temperature Limits: 0 to 140 deg F (Minus 18 to 60 deg C).
 - f. Compensate Temperature Limits: 20 to 120 deg F (Minus 7 to 49 deg C).
 - g. Thermal Effects: 0.02 percent of full scale per degree F.
2. Display: Digital with minimum 0.4-inch- (10-mm-) high numeric characters.
3. Operator Interface: Zero and span adjustments.
4. Analog Output Current Signal:
 - a. Two-wire, 4- to 20-mA dc current source.

- b. Signal capable of operating into a 1200-ohm load.

5. Construction:

- a. Plastic casing with removable clear plastic cover.
- b. Integral barbed fittings for rubber or plastic tubing connections on bottom of instrument case for high- and low-pressure connections.
- c. Screw terminal block for wire connections.
- d. Vertical plane mounting.
- e. NEMA 250, Type 4X.
- f. Mounting Bracket: Appropriate for installation.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.
- B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates 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 instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.
- C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
 2. If possible, avoid or limit use of materials in corrosive environments.
 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 PRESSURE INSTRUMENT INSTALLATION

- A. Mounting Location:
1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
 2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
 6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 3 percent.
 7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 3 percent.
- B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- C. Duct Pressure Sensors:
1. Install sensors using manufacturer's recommended upstream and downstream distances.
 2. Unless indicated on Drawings, locate sensors approximately [50] [67] [75] percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
 3. Install mounting hardware and gaskets to make sensor installation airtight.
 4. Route tubing from the sensor to transmitter.
 5. Use compression fittings at terminations.
 6. Install sensor in accordance with manufacturer's instructions.
 7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.
- D. Outdoor Pressure Sensors:
1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
 2. Locate wall-mounted sensor in an inconspicuous location.
 3. Submit sensor location for approval before installation.
 4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
 5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
 6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
 7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
 8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.
- E. Air-Pressure Differential Switches:
1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
 2. A single sensor may be used to share a common signal to multiple pressure instruments.
 3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
 4. Route NPS 3/8 (DN 12) tubing from sensor to switch connection.
 5. Do not mount switches on rotating equipment.
 6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
 7. Install switches in an easily accessible location serviceable from floor.

8. Install switches adjacent to system control panel if within 50 feet (15 m); otherwise, locate switch in vicinity of system connection.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.6 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
 4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.
 5. Provide diagnostic and test equipment for calibration and adjustment.
 6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
 7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.8 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.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record videos on DVD disks.
- D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.23

SECTION 23 09 23.27 - TEMPERATURE INSTRUMENTS

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. Air temperature sensors.
 - 2. Combination air temperature sensors and switches.
 - 3. Air temperature switches.
 - 4. Air temperature RTD transmitters.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

- A. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- B. RTD: Resistance temperature detector.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product 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. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation 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. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
3. Sizes and locations of wall access panels for instruments installed behind walls.
4. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Field quality-control reports.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 4.
 - b. Outdoors, Unprotected: Type 4X.
 - c. Indoors, Heated with Filtered Ventilation: Type 2.
 - d. Indoors, Heated with Non-Filtered Ventilation: Type 2
 - e. Indoors, Heated and Air Conditioned: Type 2.
 - f. Mechanical Equipment Rooms:
 - 1) Air-Moving Equipment Rooms: Type 12.
 - g. Localized Areas Exposed to Washdown: Type 4X
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
 - j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
 - a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
 - b. Interchangeable Accuracy: At 32 deg F (zero deg C) within 0.5 deg F (0.3 deg C).
 - c. Repeatability: Within 0.5 deg F (0.3 deg C).
 - d. Self-Heating: Negligible.
4. Transmitter Requirements:
 - a. Transmitter required for each 100-ohm RTD.
 - b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. [100] [or] [1000] ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches (450 mm) long).
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.

7. Conduit Connection: 1/2-inch (16-mm) trade size.)

C. Platinum RTD, Air Temperature Averaging Sensors:

1. [100] [or] [1000] ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch (16-mm) trade size.)

D. Platinum RTD Outdoor Air Temperature Sensors:

1. [100] [or] [1000] ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch (16-mm) trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. [100] [or] [1000] ohms.
2. Temperature Range: Minus 50 to 212 deg F (Minus 45 to 100 deg C).
3. Sensor assembly shall include a temperature sensing element mounted under a [bright white, non-yellowing, plastic] [flush, brushed-aluminum] cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
 - a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
 - b. Interchangeable Accuracy: At 77 deg F (25 deg C) within 0.5 deg F (0.3 deg C).
 - c. Repeatability: Within 0.5 deg F (0.3 deg C).
 - d. Drift: Within 0.5 deg F (0.3 deg C) over 10 years.
 - e. Self-Heating: Negligible.
4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches (450 mm) long).
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2- inch (16-mm) trade size.

H. Thermistor Averaging Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
5. Length: As required by application to cover entire cross section of air tunnel.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch (16-mm) trade size.

I. Thermistor Outdoor Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. Conduit Connection: 1/2-inch (16-mm) trade size.

J. Thermistor Space Air Temperature Sensors:

1. Temperature Range: Minus 50 to 212 deg F (Minus 45 to 100 deg C).
2. Sensor assembly shall include a temperature sensing element mounted under a [bright white, non-yellowing, plastic] [flush, brushed-aluminum] cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. [100-] [or] [1000-]ohm platinum RTD[or thermistor].
2. Thermistor:
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 - b. Thermistor drift shall be less than plus or minus 0.5 deg F (0.3 deg C) over 10 years.
3. Temperature Transmitter Requirements:

- a. Mating transmitter required with each 100-ohm RTD.
 - b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.
4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
 - a. Local override to turn HVAC on.
 - b. Local adjustment of temperature set point.
 - c. Both features shall be capable of manual override through control system operator.

2.3 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. Combination temperature sensor and switch in same instrument.
- C. Air Temperature Switch:
 1. Factory preset set point of 38 deg F (3 deg C). Field-adjustable set point from 30 to 44 deg F (minus 1 to 7 deg C).
 2. Responsive to coldest 12-inch (300-mm) section of sensor length.
 3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual reset at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.
- D. Air Temperature Sensor:
 1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
 2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 3. Accuracy: Within 0.9 deg F (0.5 deg C).
 4. Output Signal: 4 to 20 mA for connection to remote monitoring.
 5. Encase RTDs in a flexible nominal 0.375-inch- (9-mm-) diameter sheath constructed of brass.
 6. Lead wires shall be 18-gage AWG copper.
 7. Enclosure: NEMA 250, Type 4.

2.4 AIR TEMPERATURE SWITCHES

- A. Thermostat and Switch for Low Temperature Control in Duct Applications:
 1. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:
 - a. Operating Temperature Range: 15 to 55 deg F (Minus 9 to 13 deg C).
 - b. Temperature Differential: 5 deg F (2.8 deg C), non-adjustable and additive.
 - c. Enclosure Ambient Temperature: Minus 20 to 140 deg F (Minus 11 to 60 deg C).
 - d. Sensing Element Maximum Temperature: 250 deg F (121 deg C).
 - e. Voltage: 120-V ac.
 - f. Current: 16 FLA.
 - g. Switch Type: Two SPDT snap switches operate on coldest 12-inch (300-mm) section along element length.
 3. Construction:
 - a. Vapor-Filled Sensing Element: Nominal 20 feet (6 m) long.
 - b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal, NEMA 250, Type 1.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: 1/2-inch (16-mm) trade size.
- B. Thermostat and Switch for High Temperature Control in Duct Applications:
1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
 2. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 3. Performance:
 - a. Temperature Range: 100 to 160 deg F (38 to 71 deg C).
 - b. Temperature Differential: 5 deg F (2.8 deg C).
 - c. Ambient Temperature: Zero to 260 deg F (Minus 18 to 127 deg C).
 - d. Voltage: 120-V ac.
 - e. Current: 16 FLA.
 - f. Switch Type: SPDT snap switch.
 4. Construction:
 - a. Sensing Element: Helical bimetal.
 - b. Enclosure: Metal, NEMA 250, Type 1.
 - c. Electrical Connections: Screw terminals.
 - d. Conduit Connection: 1/2-inch (16-mm) trade size.

2.5 AIR TEMPERATURE RTD TRANSMITTERS

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. House electronics in NEMA 250 enclosure.
 - 1. Duct: Type 3.
 - 2. Outdoor: Type 4X.
 - 3. Space: Type 1.
- C. Conduit Connection: 1/2-inch (16-mm) trade size.)
- D. Functional Characteristics:
 - 1. Input:
 - a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - 2. Span (Adjustable):
 - a. Space: 40 to 90 deg F (4 to 32 deg C).
 - b. Supply Air Cooling and Heating: 40 to 120 deg F (4 to 49 deg C).
 - c. Supply Air Cooling Only: 40 to 90 deg F (4 to 32 deg C).
 - d. Supply Air Heating Only: 40 to 120 deg F (4 to 49 deg C).
 - e. Exhaust Air: 50 to 100 deg F (10 to 38 deg C).
 - f. Return Air: 50 to 100 deg F (10 to 38 deg C).
 - g. Mixed Air: Minus 40 to 140 deg F (Minus 40 to 60 deg C).
 - h. Outdoor: Minus 40 to 140 deg F (Minus 40 to 60 deg C).
 - 3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc .
 - 4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F (28 deg C).
 - 5. Match sensor with temperature transmitter and factory calibrate together.
- E. Performance Characteristics:
 - 1. Calibration Accuracy: Within 0.1 percent of the span.
 - 2. Stability: Within 0.2 percent of the span for at least 6 months.
 - 3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
- C. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

- a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
 - b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
 - 2) Do not begin installation without submittal approval of mounting location.
 - c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
- 2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
 - 3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 - 4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 - 5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

- 1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
- 2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches (1500 mm).

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches (610 mm) in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. (1.86 sq. m) and larger.

2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.6 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

3.7 CHECK-OUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check temperature instruments for proper location and accessibility.
- C. Verify sensing element type and proper material.
- D. Verify location and length.
- E. Verify that wiring is correct and secure.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.

5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

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 installations, including connections.

C. Perform the following tests and inspections:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.10 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.

3.11 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.
- B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:
 - 1. Software programming.
 - 2. Calibration and test procedures.
 - 3. Operation and maintenance requirements and procedures.
 - 4. Troubleshooting procedures.
- C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- D. Record videos on DVD disks.
- E. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.27

SECTION 23 11 23 - FACILITY NATURAL-GAS 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. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Manual gas shutoff valves.
 - 5. Motorized gas valves.
 - 6. Earthquake valves.
 - 7. Pressure regulators.
 - 8. Service meters.
 - 9. Dielectric fittings.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Corrugated, stainless-steel tubing with associated components.
 - 3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 4. Pressure regulators. Indicate pressure ratings and capacities.
 - 5. Service meters. Indicate pressure ratings and capacities. Include bypass fittings and meter bars.
 - 6. Dielectric fittings.

- B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. Shop Drawing Scale: 1/4 inch per foot (1:50).
 - 2. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.
- C. Delegated-Design Submittal: For natural-gas piping and equipment 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 seismic restraints.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- C. Qualification Data: For qualified professional engineer.
- D. Welding certificates.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Steel Support 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.
- 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.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

1.9 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Owner no fewer than ten days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.10 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
 - 2. Service Regulators: 100 psig (690 kPa) minimum unless otherwise indicated.
 - 3. Minimum Operating Pressure of Service Meter: 10 psig (69 kPa).
- B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

- C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
6. Mechanical Couplings:
 - a. Stainless-steel flanges and tube with epoxy finish.
 - b. Buna-nitrile seals.
 - c. Stainless-steel bolts, washers, and nuts.
 - d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

- B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.

1. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
2. Coating: PE with flame retardant.
 - a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 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.
3. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.

4. Striker Plates: Steel, designed to protect tubing from penetrations.
5. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
6. Operating-Pressure Rating: 5 psig (34.5 kPa).

2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. 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 NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.

3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
 4. CWP Rating: 750 psig (5170 kPa).
- F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.5 MANUAL GAS SHUTOFF VALVES

- A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig (862 kPa).
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig (862 kPa).
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. BrassCraft Manufacturing Co.; a Masco company.

2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. BrassCraft Manufacturing Co.; a Masco company.
 2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- F. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B 584.
 2. Plug: Bronze.
 3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Operator: Square head or lug type with tamperproof feature where indicated.
 5. Pressure Class: 125 psig (862 kPa).
 6. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- G. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Body: Cast iron, complying with ASTM A 126, Class B.
 2. Plug: Bronze or nickel-plated cast iron.
 3. Seat: Coated with thermoplastic.
 4. Stem Seal: Compatible with natural gas.
 5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 6. Operator: Square head or lug type with tamperproof feature where indicated.

7. Pressure Class: 125 psig (862 kPa).
 8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- H. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
1. Body: Cast iron, complying with ASTM A 126, Class B.
 2. Plug: Bronze or nickel-plated cast iron.
 3. Seat: Coated with thermoplastic.
 4. Stem Seal: Compatible with natural gas.
 5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 6. Operator: Square head or lug type with tamperproof feature where indicated.
 7. Pressure Class: 125 psig (862 kPa).
 8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- I. Valve Boxes:
1. Cast-iron, two-section box.
 2. Top section with cover with "GAS" lettering.
 3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
 4. Adjustable cast-iron extensions of length required for depth of bury.
 5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.6 MOTORIZED GAS VALVES

- A. Electrically Operated Valves: Comply with UL 429.
1. Pilot operated.
 2. Body: Brass or aluminum.
 3. Seats and Disc: Nitrile rubber.
 4. Springs and Valve Trim: Stainless steel.
 5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
 6. NEMA ICS 6, Type 4, coil enclosure.
 7. Normally closed.
 8. Visual position indicator.

2.7 PRESSURE REGULATORS

- A. General Requirements:
1. Single stage and suitable for natural gas.
 2. Steel jacket and corrosion-resistant components.
 3. Elevation compensator.
 4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

- B. Service Pressure Regulators: Comply with ANSI Z21.80.
 - 1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - 2. Springs: Zinc-plated steel; interchangeable.
 - 3. Diaphragm Plate: Zinc-plated steel.
 - 4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - 5. Orifice: Aluminum; interchangeable.
 - 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - 7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - 8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 - 9. Overpressure Protection Device: Factory mounted on pressure regulator.
 - 10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - 11. Maximum Inlet Pressure: 100 psig (690 kPa).
- C. Line Pressure Regulators: Comply with ANSI Z21.80.
 - 1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - 2. Springs: Zinc-plated steel; interchangeable.
 - 3. Diaphragm Plate: Zinc-plated steel.
 - 4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - 5. Orifice: Aluminum; interchangeable.
 - 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - 7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 - 8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 - 9. Overpressure Protection Device: Factory mounted on pressure regulator.
 - 10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - 11. Maximum Inlet Pressure: 10 psig (69 kPa).
- D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
 - 1. Body and Diaphragm Case: Die-cast aluminum.
 - 2. Springs: Zinc-plated steel; interchangeable.
 - 3. Diaphragm Plate: Zinc-plated steel.
 - 4. Seat Disc: Nitrile rubber.
 - 5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - 6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 - 7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
 - 8. Maximum Inlet Pressure: 2 psig (13.8 kPa).

2.8 SERVICE METERS

- A. Diaphragm-Type Service Meters: Comply with ANSI B109.1.
 - 1. Case: Die-cast aluminum.
 - 2. Connections: Steel threads.
 - 3. Diaphragm: Synthetic fabric.
 - 4. Diaphragm Support Bearings: Self-lubricating.

5. Compensation: Continuous temperature.
 6. Meter Index: Cubic feet.
 7. Meter Case and Index: Tamper resistant.
 8. Remote meter reader compatible.
 9. Maximum Inlet Pressure: 100 psig (690 kPa).
 10. Pressure Loss: Maximum 2.0-inch wg (498 Pa).
 11. Accuracy: Maximum plus or minus 1.0 percent.
- B. Rotary-Type Service Meters: Comply with ANSI B109.3.
1. Case: Extruded aluminum.
 2. Connection: Flange.
 3. Impellers: Polished aluminum.
 4. Rotor Bearings: Self-lubricating.
 5. Compensation: Continuous temperature.
 6. Meter Index: Cubic feet.
 7. Tamper resistant.
 8. Remote meter reader compatible.
 9. Maximum Inlet Pressure: 100 psig (690 kPa).
 10. Accuracy: Maximum plus or minus 2.0 percent.
- C. Turbine Meters: Comply with ASME MFC-4M.
1. Housing: Cast iron or welded steel.
 2. Connection Threads or Flanges: Steel.
 3. Turbine: Aluminum or plastic.
 4. Turbine Bearings: Self-lubricating.
 5. Compensation: Continuous temperature.
 6. Meter Index: Cubic feet.
 7. Tamper resistant.
 8. Remote meter reader compatible.
 9. Maximum Inlet Pressure: 100 psig (690 kPa).
 10. Accuracy: Maximum plus or minus 2.0 percent.
- D. Service-Meter Bars:
1. Malleable- or cast-iron frame for supporting service meter.
 2. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
 3. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.
- E. Service-Meter Bypass Fittings:
1. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
 2. Integral ball-check bypass valve.
- 2.9 DIELECTRIC FITTINGS
- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
1. Description:

- a. Standard: ASSE 1079.
 - b. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [250 psig (1725 kPa)]**.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [175 psig (1200 kPa)] [300 psig (2070 kPa)]**.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
 - 1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: **[150 psig (1035 kPa)]**.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

2.10 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

- C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- E. Copper Tubing with Protective Coating:
 - 1. Apply joint cover kits over tubing to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- F. Install fittings for changes in direction and branch connections.
- G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.

- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - 3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 - 4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 5. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

- b. Do not install natural-gas piping in solid walls or partitions.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."
- 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."

3.5 SERVICE-METER ASSEMBLY INSTALLATION

- A. Install service-meter assemblies aboveground, on concrete bases.
- B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
- C. Install strainer on inlet of service-pressure regulator and meter set.
- D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
- E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
- F. Install service meters downstream from pressure regulators.
- G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.

3.7 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. 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:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
- G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
- H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.8 HANGER AND SUPPORT INSTALLATION

- A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
 - 2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 - 4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
 - 5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).
- D. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
 - 2. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 - 3. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
 - 4. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
- E. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
 - 2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 - 3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.9 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 PAINTING

- A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.
- B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel (flat).
 - d. Color: Gray.
- C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior latex matching topcoat.
 - c. Topcoat: Interior latex (low sheen).
 - d. Color: Gray.
 - 2. Alkyd System: MPI INT 5.1E.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior alkyd matching topcoat.
 - c. Topcoat: Interior alkyd (flat).
 - d. Color: Gray.
- D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Use 3000-psig (20.7-MPa), 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.13 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.14 DEMONSTRATION

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

3.15 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be the following:
 - 1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
- B. Aboveground natural-gas piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

- 3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)
- A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - B. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
 - C. Underground, below building, piping shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
 - E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- 3.17 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 2 PSIG (34.5 kPa)
- A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - B. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with steel welding fittings and welded joints.
 - C. Underground, below building, piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
 - D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
 - E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- 3.18 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 2 PSIG (34.5 kPa)
- A. Aboveground Piping: Maximum operating pressure no more than 2 psig (34.5 kPa)].
 - B. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.
 - C. Aboveground, distribution piping shall be the following:

1. Steel pipe with steel welding fittings and welded joints.
- D. Underground, below building, piping shall be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
 2. Steel pipe with wrought-steel fittings and welded joints.
- E. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- F. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.19 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
- B. Underground:
1. NPS 2 (DN 50) and Smaller: Bronze plug valves.
 2. NPS 2-1/2 (DN 65) and Larger: Cast-iron, nonlubricated plug valves.

3.20 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
- B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
 2. Cast-iron, nonlubricated plug valve.
- C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
- D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
 2. Cast-iron, nonlubricated plug valve.
- E. Valves in branch piping for single appliance shall be the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION 231123

SECTION 23 21 13 - HYDRONIC 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 pipe and fitting materials and joining methods for the following:
 - 1. Copper tube and fittings.
 - 2. Steel pipe and fittings.
 - 3. Plastic pipe and fittings.
 - 4. Joining materials.
 - 5. Transition fittings.
 - 6. Dielectric fittings.
 - 7. Bypass chemical feeder.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Pipe.
 - 2. Fittings.
 - 3. Joining materials.
 - 4. Bypass chemical feeder.
- 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 firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, 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. Other building services.
 3. Structural members.
- B. Qualification Data: For Installer.
- C. Welding certificates.
- D. Field quality-control reports.
- E. Preconstruction Test Reports:
1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with 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.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on water quality.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Condensate-Drain Piping: 180 deg F (82 deg C).
 2. Air-Vent Piping: 200 deg F (93 deg C).

3. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type M (ASTM B 88M, Type C).
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Victaulic Company.
 2. Grooved-End Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze casting.
 3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F (110 deg C) for use with housing, and steel bolts and nuts.
- E. Copper or Bronze Pressure-Seal Fittings:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Products Corporation.
 - b. Mueller Industries, Inc.
 - c. Viega LLC.
 2. Housing: Copper.
 3. O-Rings and Pipe Stops: EPDM.
 4. Tools: Manufacturer's special tools.
 5. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).
- F. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

- D. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- E. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- F. Wrought Cast- and Forged-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.
- G. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Grinnell Mechanical Products.
 - c. Victaulic Company.
 - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

- A. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.
 - 1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 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 (3.2-mm) 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. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.6 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Fittings:
 - 1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- B. Plastic-to-Metal Transition Unions:
 - 1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Flanges:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)]**.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- C. Dielectric-Flange Insulating Kits:
 - 1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: **[150 psig (1035 kPa)]**.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.
- D. Dielectric Nipples:
 - 1. Description:
 - a. Standard: IAPMO PS 66.

- b. Electroplated steel nipple, complying with ASTM F 1545.
- c. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
- d. End Connections: Male threaded or grooved.
- e. Lining: Inert and noncorrosive, propylene.

2.8 BYPASS CHEMICAL FEEDER

- A. Description: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.
 - 1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
 - 1. Type M (Type C), drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
 - 2. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- B. Hot-water heating piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
 - 1. Type M (Type C), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 - 2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- C. Hot-water heating piping installed belowground and within slabs shall be the following:
 - 1. Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.
 - 2. RTRP and RTRF with adhesive or flanged joints.
- D. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. Copper piping must be insulated.
- E. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- F. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

2. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.

- G. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate 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 specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to Section 230523.11 "Valves for HVAC Piping." Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
- R. Install shutoff valve immediately upstream of each dielectric fitting.

- S. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- U. 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."
- V. 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."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges or nipples.
- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.4 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.
- B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
 - 2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).

3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
 4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
 5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
 6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).
- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
- F. Plastic 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.
- G. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 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. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 - 3. PVC Nonpressure Piping: Join according to ASTM D 2855.
- I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
 - 1. pH: 9.0 to 10.5.
 - 2. "P" Alkalinity: 100 to 500 ppm.
 - 3. Boron: 100 to 200 ppm.
 - 4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
 - 5. Corrosion Inhibitor:
 - a. Chromate Plus Molybdate: 50 to 100 ppm each.
 - 6. Soluble Copper: Maximum of 0.20 ppm.
 - 7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
 - 8. Total Suspended Solids: Maximum of 10 ppm.
 - 9. Ammonia: Maximum of 20 ppm.
 - 10. Free Caustic Alkalinity: Maximum of 20 ppm.
 - 11. Microbiological Limits:

- a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
 - b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
 - c. Nitrate Reducers: 100 organisms/mL.
 - d. Sulfate Reducers: Maximum of zero organisms/mL.
 - e. Iron Bacteria: Maximum of zero organisms/mL.
- B. Install bypass chemical feeders in each hydronic system where indicated.
1. Install in upright position with top of funnel not more than 48 inches (1200 mm) above the floor.
 2. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
 3. Install NPS 3/4 (DN 20) pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.8 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 23 21 16 - HYDRONIC 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:
 - 1. Hydronic specialty valves.
 - 2. Air-control devices.
 - 3. Strainers.
 - 4. Connectors.
- B. Related Requirements:
 - 1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product:
 - 1. Include construction details and material descriptions for hydronic piping specialties.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

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

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - 2. Ball: Brass or stainless steel.
 - 3. Plug: Resin.
 - 4. Seat: PTFE.
 - 5. End Connections: Threaded or socket.
 - 6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 7. Handle Style: Lever, with memory stop to retain set position.
 - 8. CWP Rating: Minimum 125 psig (860 kPa).
 - 9. Maximum Operating Temperature: 250 deg F (121 deg C).
- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
 - 1. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 - 2. Ball: Brass or stainless steel.
 - 3. Stem Seals: EPDM O-rings.
 - 4. Disc: Glass and carbon-filled PTFE.
 - 5. Seat: PTFE.
 - 6. End Connections: Flanged or grooved.
 - 7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 8. Handle Style: Lever, with memory stop to retain set position.
 - 9. CWP Rating: Minimum 125 psig (860 kPa).
 - 10. Maximum Operating Temperature: 250 deg F (121 deg C).
- C. Automatic Flow-Control Valves:
 - 1. Body: Brass or ferrous metal.
 - 2. Flow Control Assembly, provide either of the following:
 - a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
 - b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig (14- to 550-kPa) differential pressure.
 - 3. Combination Assemblies: Include bronze or brass-alloy ball valve.
 - 4. Identification Tag: Marked with zone identification, valve number, and flow rate.
 - 5. Size: Same as pipe in which installed.
 - 6. Performance: Maintain constant flow within plus or minus 5 percent, regardless of system pressure fluctuations.

7. Minimum CWP Rating: 175 psig (1207 kPa).
8. Maximum Operating Temperature: 200 deg F (93 deg C).

2.2 AIR-CONTROL DEVICES

- A. Manual Air Vents:
1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Screwdriver or thumbscrew.
 4. Inlet Connection: NPS 1/2 (DN 15).
 5. Discharge Connection: NPS 1/8 (DN 6).
 6. CWP Rating: 150 psig (1035 kPa).
 7. Maximum Operating Temperature: 225 deg F (107 deg C).
- B. Automatic Air Vents:
1. Body: Bronze or cast iron.
 2. Internal Parts: Nonferrous.
 3. Operator: Noncorrosive metal float.
 4. Inlet Connection: NPS 1/2 (DN 15).
 5. Discharge Connection: NPS 1/4 (DN 8).
 6. CWP Rating: 150 psig (1035 kPa).
 7. Maximum Operating Temperature: 240 deg F (116 deg C).

2.3 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 NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
 4. CWP Rating: 125 psig (860 kPa).
- B. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 4. CWP Rating: 125 psig (860 kPa).
- C. T-Pattern Strainers:
1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 2. End Connections: Grooved ends.
 3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.

4. CWP Rating: 750 psig (5170 kPa).

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
- D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

END OF SECTION 232116

SECTION 23 21 23 - HYDRONIC PUMPS

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. Automatic condensate pump units.

1.3 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: For each pump.
 - 1. Show pump layout and connections.
 - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

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

1.6 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.

PART 2 - PRODUCTS

2.1 AUTOMATIC CONDENSATE PUMP UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Little Giant Pump Co.
 - 2. Mepco, LLC.
- B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check, shutoff, and throttling valves on discharge side of pumps.
- F. Install suction diffuser and shutoff valve on suction side of pumps.

- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- I. Install check valve and gate or ball valve on each condensate pump unit discharge.
- J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 23 00 - 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 layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
 - 2. 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.
 - 3. Show interface and spatial relationships between piping and equipment.
 - 4. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).

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-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8/A5.8M.
- E. 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 (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

4. Working Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.
- B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
- C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.
- D. 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.
- E. Flanged Unions:
 1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.
 2. Gasket: Fiber asbestos free.
 3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
 4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
 5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 6. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
 7. Maximum Operating Temperature: 330 deg F (165 deg C).
- F. Flexible Connectors:
 1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
 2. End Connections:
 - a. NPS 2 (DN 50) and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.
 3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
 5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.4 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Parker Hannifin Corp.
 - c. Paul Mueller Company.

2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
4. Operator: Rising stem and hand wheel.
5. Seat: Nylon.
6. End Connections: Socket, union, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

B. Packed-Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
2. Body and Bonnet: Forged brass or cast bronze.
3. Packing: Molded stem, back seating, and replaceable under pressure.
4. Operator: Rising stem.
5. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
6. Seal Cap: Forged-brass or valox hex cap.
7. End Connections: Socket, union, threaded, or flanged.
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

C. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
2. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
3. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
4. Piston: Removable polytetrafluoroethylene seat.
5. Closing Spring: Stainless steel.
6. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
7. End Connections: Socket, union, threaded, or flanged.
8. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.

- c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
 - 2. Body: Forged brass with brass cap including key end to remove core.
 - 3. Core: Removable ball-type check valve with stainless-steel spring.
 - 4. Seat: Polytetrafluoroethylene.
 - 5. End Connections: Copper spring.
 - 6. Working Pressure Rating: 500 psig (3450 kPa).
- E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
 - 2. Body and Bonnet: Plated steel.
 - 3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 - 4. Seat: Polytetrafluoroethylene.
 - 5. End Connections: Threaded.
 - 6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [24] [115] [208]-V ac coil.
 - 7. Working Pressure Rating: 400 psig (2760 kPa).
 - 8. Maximum Operating Temperature: 240 deg F (116 deg C).
- F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
 - 2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 - 3. Piston, Closing Spring, and Seat Insert: Stainless steel.
 - 4. Seat: Polytetrafluoroethylene.
 - 5. End Connections: Threaded.
 - 6. Working Pressure Rating: 400 psig (2760 kPa).
 - 7. Maximum Operating Temperature: 240 deg F (116 deg C).
- G. Thermostatic Expansion Valves: Comply with AHRI 750.
- 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.
 - 2. Body, Bonnet, and Seal Cap: Forged brass or steel.
 - 3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 - 4. Packing and Gaskets: Non-asbestos.
 - 5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 - 6. Suction Temperature: 40 deg F (4.4 deg C).
 - 7. Superheat: Adjustable.
 - 8. Reverse-flow option (for heat-pump applications).
 - 9. End Connections: Socket, flare, or threaded union.
 - 10. Working Pressure Rating: 700 psig (4820 kPa).
- H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - 2. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 - 3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 - 4. Packing and Gaskets: Non-asbestos.
 - 5. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 - 6. Seat: Polytetrafluoroethylene.
 - 7. Equalizer: Internal.
 - 8. End Connections: Socket.
 - 9. Throttling Range: Maximum 5 psig (34 kPa).
 - 10. Working Pressure Rating: 500 psig (3450 kPa).
 - 11. Maximum Operating Temperature: 240 deg F (116 deg C).
- I. Straight-Type Strainers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - 2. Body: Welded steel with corrosion-resistant coating.
 - 3. Screen: 100-mesh stainless steel.
 - 4. End Connections: Socket or flare.
 - 5. Working Pressure Rating: 500 psig (3450 kPa).
 - 6. Maximum Operating Temperature: 275 deg F (135 deg C).
- J. Angle-Type Strainers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.

- c. Parker Hannifin Corp.
 - 2. Body: Forged brass or cast bronze.
 - 3. Drain Plug: Brass hex plug.
 - 4. Screen: 100-mesh monel.
 - 5. End Connections: Socket or flare.
 - 6. Working Pressure Rating: 500 psig (3450 kPa).
 - 7. Maximum Operating Temperature: 275 deg F (135 deg C).
- K. Moisture/Liquid Indicators:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - 2. Body: Forged brass.
 - 3. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 - 4. Indicator: Color coded to show moisture content in parts per million (ppm).
 - 5. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 - 6. End Connections: Socket or flare.
 - 7. Working Pressure Rating: 500 psig (3450 kPa).
 - 8. Maximum Operating Temperature: 240 deg F (116 deg C).
- L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - 2. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 - 3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - 4. Desiccant Media: Activated alumina.
 - 5. Designed for reverse flow (for heat-pump applications).
 - 6. End Connections: Socket.
 - 7. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 - 8. Maximum Pressure Loss: 2 psig (14 kPa).
 - 9. Working Pressure Rating: 500 psig (3450 kPa).
 - 10. Maximum Operating Temperature: 240 deg F (116 deg C).
- M. Permanent Filter Dryers: Comply with AHRI 730.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.

c. Parker Hannifin Corp.

2. Body and Cover: Painted-steel shell.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated alumina.
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: 2 psig (14 kPa).
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

N. Mufflers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

O. 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 (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

P. 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 (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.5 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. DuPont Fluorochemicals Div.
 - b. Genetron Refrigerants; Honeywell International Inc.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
- C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.
- D. Safety-Relief-Valve Discharge Piping:
 - 1. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
- E. Safety-Relief-Valve Discharge Piping NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. 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.
- B. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- C. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- D. Install a full-size, three-valve bypass around filter dryers.
- E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- F. 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.
- G. 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.
- H. 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.

- I. 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.
- J. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- K. Install receivers sized to accommodate pump-down charge.
- L. 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.
- 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. Shot blast the interior of piping.
 - 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - 3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 4. 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.
 - 5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 - 6. 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."
- 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 (6 m) long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) 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 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).
 - 2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).
 - 3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod, 1/4 inch (6.4 mm).
 - 4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
 - 5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
 - 6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
 - 7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod, 3/8 inch (9.5 mm).
 - 8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
 - 9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod, 1/2 inch (13 mm).
- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
 - 2. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod, 3/8 inch (9.5 mm).

3. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod, 3/8 inch (9.5 mm).
4. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod, 1/2 inch (13 mm).

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 (67 Pa). 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 (14 kPa).
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 23 31 13 - 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. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.

- B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
3. 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

- 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 shall withstand the effects of gravity and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
- 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.

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, and vibration isolation.

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.

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 the following, as applicable:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2.
 - 3. 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 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- 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."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- 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.

- B. 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."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
- C. 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 (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
- D. 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."

2.3 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.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 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 (Z275).
 - 2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils (0.10 mm) thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil (0.025 mm) 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 304 or 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 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

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.
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 (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 DUCT LINER

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

a. Maximum Thermal Conductivity:

- 1)
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
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]-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick stainless steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

C. 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.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) 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 (12.7 m/s) or where indicated.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
10. 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.

2.5 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.
- 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 (102 mm).
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. 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 (2500 Pa), 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.

D. 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.

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

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
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.

2.6 HANGERS AND SUPPORTS

- 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 (Table 5-1M), "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.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- 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.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- 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 (38 mm).
- 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 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."

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.

3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

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

- 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 (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "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 (610 mm) of each elbow and within 48 inches (1200 mm) 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 intervals of 16 feet (5 m).
- 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.

3.5 CONNECTIONS

- 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.

3.6 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."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- 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:

- a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Supply Ducts with a Pressure Class of 3-Inch wg (750 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - d. Exhaust Ducts with a Pressure Class of 3-Inch wg (750 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - e. Outdoor Air Ducts with a Pressure Class of 3-Inch wg (750 Pa) or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 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.
 - 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.
 - D. Duct system will be considered defective if it does not pass tests and inspections.
 - E. Prepare test and inspection reports.
- 3.8 DUCT CLEANING
- 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.

3.9 START UP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, PVC-coated, galvanized sheet steel with thicker coating on duct exterior.
2. .

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Constant-Volume Air-Handling Units:
 - a. Pressure Class: Positive 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
 - a. Pressure Class: Positive 4-inch wg (1000 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 6 .
 - d. SMACNA Leakage Class for Round and Flat Oval: 3.
4. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
3. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Negative 2-inch wg (500 Pa).
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 24.
- d. SMACNA Leakage Class for Round and Flat Oval: 12.

D. Exhaust Ducts:

- 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

- 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 3-inch wg (750 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Carbon steel coated with zinc-chromate primer.
 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.
- G. Liner:
1. Supply Air Ducts: Fibrous glass, Type I, 1 inch (25 mm) thick.
 2. Return Air Ducts: Fibrous glass, Type I, 1 inch (25 mm) thick.
 3. Exhaust Air Ducts: Fibrous glass, Type I, 1 inch (25 mm) thick.
 4. Supply Fan Plenums: Fibrous glass, Type II, 2 inches (51 mm) thick.
 5. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II, 2 inches (51 mm) thick.
 6. Transfer Ducts: Fibrous glass, Type I, 1-1/2 inches (38 mm) thick.
- H. Double-Wall Duct Interstitial Insulation:
1. Supply Air Ducts: 1-1/2 inches (38 mm) thick.
 2. Return Air Ducts: 1 inch (25 mm) thick.
 3. Exhaust Air Ducts: 1 inch (25 mm) thick.
- I. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) 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 (5 to 7.6 m/s):
 - 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 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 (7.6 m/s) 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 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. No vanes shall be installed in rectangular return and exhaust elbows. Select a listed elbow without vanes from Paragraph 1 above.
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.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.

J. 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 (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 23 33 00 - 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. Smoke dampers.
7. Combination fire and smoke dampers.
8. Corridor dampers.
9. Flange connectors.
10. Duct silencers.
11. Turning vanes.
12. Remote damper operators.
13. Duct-mounted access doors.
14. Flexible connectors.
15. Duct accessory hardware.

- B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible 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 (Z275).
 - 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 (ASTM B 209M), 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 (ASTM B 221M), Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cesco Products; a division of MESTEK, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. Nailor Industries Inc.
 - 4. Pottorff.
 - 5. Ruskin Company.
 - 6. Safe Air - Dowco Products.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 1250 fpm (6.4 m/s).
- D. Maximum System Pressure: 1-inch wg (0.25 kPa).
- E. Frame: Hat-shaped, 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners or mechanically attached and mounting flange.
- F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Stainless steel.
 - 2. Diameter: 0.20 inch (5 mm).
- J. Tie Bars and Brackets: Aluminum.
- 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 (1.0 mm) minimum.
 - b. Sleeve Length: 6 inches (152 mm) minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Insect.
9. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cesco Products; a division of MESTEK, Inc.
 2. Greenheck Fan Corporation.
 3. Nailor Industries Inc.
 4. Ruskin Company.
 5. Safe Air - Dowco Products.
- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 1000 fpm (5.1 m/s).
- D. Maximum System Pressure: 2-inch wg (0.5 kPa).
- E. Frame: Hat-shaped, 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners or mechanically attached and mounting flange.
- F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
1. Material: Stainless steel.
 2. Diameter: 0.20 inch (5 mm).
- J. Tie Bars and Brackets: Aluminum.
- 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 (1.0 mm) minimum.
 - b. Sleeve Length: 6 inches (152 mm) minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Insect.
9. 90-degree stops.

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. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Ruskin Company.
 - d. Safe Air - Dowco Products.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Frame: Hat-shaped, 0.05-inch- (1.3-mm-) 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. Stainless-steel, 0.064 inch (1.62 mm) thick.
6. Blade Axles: Stainless steel.
7. Bearings:
 - a. Oil-impregnated stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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. Ruskin Company.
 - d. Safe Air - Dowco Products.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) 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- (2.5-mm-) thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
6. Blade Axles: Stainless steel.
7. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Aluminum.

2.6 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cesco Products; a division of MESTEK, Inc.
 2. Greenheck Fan Corporation.
 3. McGill AirFlow LLC.
 4. Nailor Industries Inc.
 5. Ruskin Company.
 6. Safe Air - Dowco Products.
- 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 shaped.
 2. 0.05-inch- (1.3-mm-) thick stainless steel.
 3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 6 inches (152 mm).
2. Parallel- and opposed-blade design.
3. Aluminum.
4. 0.0747-inch- (1.9-mm-) thick dual skin.
5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- (13-mm-) diameter; 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 (minus 40 to plus 93 deg C).

F. Bearings:

1. Oil-impregnated stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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. Cesco Products; a division of MESTEK, Inc.
2. Greenheck Fan Corporation.
3. Nailor Industries Inc.
4. Ruskin Company.
5. Safe Air - Dowco Products.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.138 inch (3.5 mm) or 0.39 inch (9.9 mm) 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, 0.024-inch- (0.61-mm) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- I. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.8 SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Cesco Products; a division of MESTEK, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. Nailor Industries Inc.
 - 4. Ruskin Company.
 - 5. Safe Air - Dowco Products.
- B. General Requirements: Label according to UL 555S by an NRTL.
- C. Smoke Detector: Integral, factory wired for single-point connection.
- D. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded corners and mounting flange.
- E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) 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- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
- I. Damper Motors: 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 (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - 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 (minus 40 deg C).
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).

7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling.
2. Test and reset switches, remote mounted.

2.9 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Cesco Products; a division of MESTEK, Inc.
2. Greenheck Fan Corporation.
3. Nailor Industries Inc.
4. Ruskin Company.
5. Safe Air - Dowco Products.

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 (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded corners and mounting flange.

F. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Roll-formed, horizontal, interlocking, 0.063-inch- (1.6-mm-) thick, galvanized sheet steel.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

L. Master control panel for use in dynamic smoke-management systems.

M. Damper Motors: two-position action.

N. 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 (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
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 (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 115 V, single phase, 60 Hz.

O. Accessories:

1. Auxiliary switches for signaling.
2. Test and reset switches, remote mounted.

2.10 DUCT SILENCERS

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

1. Dynasonics.
2. McGill AirFlow LLC.
3. Vibro-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 (Z275), galvanized sheet steel, 0.040 inch (1.02 mm) thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275), galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.

2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.
 3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.05 inch (1.3 mm) thick.
 4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.
- F. Inner Casing and Baffles: ASTM A 653/A 653M, **[G90 (Z275)] [G60 (Z180)]** galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.
- G. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- H. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 2. Film-lined type with fill material.
 - a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.
 - b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
 3. Lining: Tedlar.
- I. 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 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.
- J. Accessories:
1. Factory-installed end caps to prevent contamination during shipping.

2.11 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Duro Dyne Inc.
 3. METALAIRE, Inc.
 4. SEMCO LLC.
 5. 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: Double wall.
- F. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.12 REMOTE DAMPER OPERATORS

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

2.13 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cesco Products; a division of MESTEK, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. McGill AirFlow LLC.
 - 4. Nailor Industries Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "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 (25-by-25-mm) 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 (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Continuous and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): 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 (800 to 2000 Pa).
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- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.14 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 (1.3-mm) carbon steel.

D. Fasteners: Stainless 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 (1093 deg C).

F. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.15 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries; a brand of Hart & Cooley, Inc.

- 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 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) 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. (880 g/sq. m).
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- 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. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
 - 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- H. 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 (6-mm) movement at start and stop.

2.16 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.

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 control 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.
- 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 (4.18-mm) steel sleeve, continuously welded at all joints and 1/2-inch- (13-mm-) diameter steel bars, 6 inches (150 mm) 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 (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) 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 (15-m) spacing.
 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 (200 by 125 mm).
 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 5. Body Access: 25 by 14 inches (635 by 355 mm).
 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- 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 (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- P. Connect diffusers or light troffer boots to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- Q. Connect flexible ducts to metal ducts with draw bands.
- R. Install duct test holes where required for testing and balancing purposes.
- S. 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 (6-mm) movement during start and stop of fans.

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 23 33 46 - FLEXIBLE 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. Non-insulated flexible ducts.
 - 2. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For flexible ducts.
 - 1. Include plans showing locations and mounting and attachment details.

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.

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.
- C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."
- D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 NON-INSULATED FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flexmaster U.S.A., Inc.
 2. McGill AirFlow LLC.
 3. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Non-Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire.
1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 2. Maximum Air Velocity: 4000 fpm (20 m/s).
 3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).

2.3 INSULATED FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flexmaster U.S.A., Inc.
 2. McGill AirFlow LLC.
 3. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 2. Maximum Air Velocity: 4000 fpm (20 m/s).
 3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
 4. Insulation R-Value: Comply with ASHRAE/IES 90.1.

2.4 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Nylon strap in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install flexible ducts 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 in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- C. Connect diffusers or light troffer boots to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

- D. Connect flexible ducts to metal ducts with draw bands.
- E. Install duct test holes where required for testing and balancing purposes.
- F. Installation:
 - 1. Install ducts fully extended.
 - 2. Do not bend ducts across sharp corners.
 - 3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
 - 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 - 5. Install flexible ducts in a direct line, without sags, twists, or turns.
- G. Supporting Flexible Ducts:
 - 1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a maximum of 48 inches (1200 mm) apart. Maximum centerline sag between supports shall not exceed 1/2 inch (13 mm) per 12 inches (300 mm).
 - 2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
 - 3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
 - 4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches (1800 mm) o.c.

END OF SECTION 233346

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 36 00 - 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. Exhaust single-duct terminal units.
 - 3. 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.
- C. Delegated-Design Submittal:
 - 1. Materials, fabrication, assembly, and spacing of hangers and supports.
 - 2. Include design calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

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 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- C. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Trane
 2. Krueger.
 3. Nailor Industries Inc.
 4. Price Industries.
 5. Titus.
 6. Tuttle & Bailey.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

- C. Casing: 0.034-inch- (0.85-mm-) thick galvanized steel, single wall.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass 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 (minus 18 to plus 60 deg C), shall be impervious to moisture and fungus, shall be suitable for 10-inch wg (2500-Pa) 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 (1500-Pa) inlet static pressure.
 - 2. Damper Position: Normally open.
- F. Attenuator Section: 0.032-inch (0.8-mm) aluminum sheet.
 - 1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for duct liner.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- G. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 1. Electronic Damper Actuator: 24 V, powered open, capacitous return.
 - 2. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
 - 3. 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."
 - 4. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
- H. Controls:
 - 1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.
 - 2. System-powered, wall-mounted thermostat.

2.3 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, 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 (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
- 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:
 - 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

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

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. Rectangular and square ceiling diffusers.
 - 2. Perforated diffusers.
 - 3. Louver face diffusers.
 - 4. Linear slot diffusers.
 - 5. Ceiling-integral continuous diffusers.
 - 6. Fixed face grilles
- B. Related Sections:
 - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

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. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.

4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 5. Duct access panels.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
 - a. Krueger.
 - b. Nailor Industries Inc.
 - c. Price Industries.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Aluminum.
4. Finish: Baked enamel, color selected by Architect.
5. Pattern: Fixed.
6. Dampers: None.
7. Accessories:
 - a. Equalizing grid.
 - b. Plaster ring.
 - c. Safety chain.
 - d. Wire guard.
 - e. Sectorizing baffles.
 - f. Operating rod extension.

B. Perforated Diffuser:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
 - a. Krueger.
 - b. Nailor Industries Inc.
 - c. Price Industries.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel backpan and pattern controllers, with steel face.
4. Finish: Baked enamel, color selected by Architect.
5. Face Style: Flush.
6. Pattern Controller: None.
7. Accessories:
 - a. Equalizing grid.
 - b. Plaster ring.

- c. Safety chain.
- d. Wire guard.
- e. Sectorizing baffles.
- f. Operating rod extension.

C. Louver Face Diffuser:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
 - a. Krueger.
 - b. Nailor Industries Inc.
 - c. Price Industries.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, color selected by Architect.
5. Pattern: Adjustable core style.
6. Dampers: None.
7. Accessories:
 - a. Square to round neck adaptor.
 - b. Adjustable pattern vanes.
 - c. Throw reducing vanes.
 - d. Equalizing grid.
 - e. Plaster ring.
 - f. Safety chain.
 - g. Wire guard.
 - h. Sectorizing baffles.
 - i. Operating rod extension.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
 - a. Krueger.
 - b. Nailor Industries Inc.
 - c. Price Industries.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: Aluminum, insulated.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: Baked enamel, color selected by architect.
6. Finish - Pattern Controller: Baked enamel, black.
7. Finish - Tees: Baked enamel, color selected by Architect.
8. Accessories: Plaster frame.

B. Ceiling-Integral Continuous Diffuser:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
 - a. Krueger.
 - b. Nailor Industries Inc.
 - c. Price Industries.
2. Straight and curved sections as required to accommodate layout.
3. Mitered tees and corners.
4. Pattern Controllers: **[24 inches (600 mm)]** o.c.
5. Material: Aluminum, extruded, heavy wall.
6. Finishes:
 - a. Exterior: Standard white.
 - b. Interior: Standard black.
7. Throw: Standard.
8. Mounting: Ceiling.
9. Plenum: Insulated.
10. Other Features:
 - a. Painted interior.
 - b. Blank-offs.

2.3 REGISTERS AND GRILLES

A. Fixed Face Grille

1. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
 - a. Krueger.
 - b. Nailor Industries Inc.
 - c. Price Industries.
2. Material: Steel.
3. Finish: Baked enamel, color selected by Architect.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 51 23 - GAS VENTS

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. Listed double-wall vents.

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 product.
- B. Shop Drawings: For vents.
 - 1. Include plans, elevations, sections, 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. Detail fabrication and assembly of hangers and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Sample Warranty: For special warranty.

1.5 QUALITY ASSURANCE

- A. 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 D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.
- B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED TYPE B AND BW VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cleaver-Brooks.
 2. Hart & Cooley Inc.
 3. Metal-Fab, Inc.
 4. Selkirk Corporation.
 5. Van-Packer Company, Inc.
- B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
- D. Inner Shell: ASTM B 209 (ASTM B 209M), Type 3105 aluminum.
- E. Outer Jacket: Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.2 LISTED TYPE L VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Metal-Fab, Inc.
 2. Selkirk Corporation.
 3. Van-Packer Company, Inc.
- B. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 2-inch (50-mm) airspace filled with high-temperature, mineral-wool insulation.
- D. Inner Shell: ASTM A 666, Type 304 stainless steel.
- E. Outer Jacket: Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Round chimney top designed to exclude 98 percent of rainfall.

2. Termination: Round side-wall designed to exclude minimum 98 percent of rainfall.

2.3 LISTED SPECIAL GAS VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Heatfab Saf-T Vent.
 2. Metal-Fab, Inc.
 3. Selkirk Corporation.
- B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.
- D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
- E. Outer Jacket: Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
 2. Termination: Round side-wall designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Listed Type B and BW Vents: Vents for certified gas appliances.
- B. Listed Type L Vent: Vents for low-heat appliances.
- C. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

- B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- E. Lap joints in direction of flow.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 235123

SECTION 23 74 13 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
 - 1. Direct-expansion cooling.
 - 2. Gas furnace.
 - 3. Economizer outdoor- and return-air damper section.
 - 4. Integral, space temperature controls.
 - 5. Roof curbs.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 7 Sections for roof curbs, and roof penetrations.
 - 2. Division 23 Section "Common Motor Requirements for HVAC Equipment".
 - 3. Division 23 Section 23 00 30 "Electrical Requirements for Mechanical Equipment".
 - 4. Division 26 Sections for power supply wiring including field-installed disconnect, and required electrical devices.
- C. Products furnished, but not installed, under this Section include roof curbs for rooftop air conditioners.

1.2 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. ECM: Electrically 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. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTU's. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged outdoor, central- station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
- F. 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.
- G. 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.
- H. VVT: Variable-air volume and temperature.

1.3 SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, locate, and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For rooftop air conditioners to include in emergency, operation, and maintenance manuals.
- E. Warranties: Special warranties specified in this Section.
- F. Startup Reports: Indicate results of startup and testing requirements. Submit copies of checklists.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop air conditioners and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- D. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- E. Comply with NFPA 54 for gas-fired furnace section.
- F. ARI Certification: Units shall be ARI certified and listed.
- G. ARI Compliance for Units with Capacities 135,000 Btuh and More: Rate rooftop air-conditioner capacity according to ARI 340/360, "Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment."
 - 1. Sound Power Level Ratings: Comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate size, location, and installation of rooftop air-conditioner manufacturer's roof curbs and equipment supports with roof installer.
 - 1. Coordinate installation of restrained vibration isolation roof-curb rails.
- C. Coordinate size and location of roof openings.
- D. Coordinate electrical power requirements.
- E. Coordinate natural gas requirements.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace, parts and labor with no cost to the owner, components of rooftop air conditioners 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 Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
 - 3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 - 4. Warranty Period for Control Boards: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 - 5. Warranty Period for Variable-Speed Fan Motors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 - 6. Warranty Period for Electronic Thermostats: Manufacturer's standard, but not less than ten years from date of Substantial Completion.

1.7 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 ROOFTOP AIR CONDITIONERS

- A. Manufacturers:
 - 1. AAON, Inc.
 - 2. Daikin Applied

3. YORK, a Johnson Controls Company
 4. Johnson Controls, Inc.
 5. Carrier Corporation, a unit of United Technologies Corp.
 6. Trane.
- B. Description: Factory assembled and tested; designed for exterior installation; consisting of compressor, indoor and outside refrigerant coils, indoor fan and outside coil fan, refrigeration and temperature controls, filters, and dampers. Unit to be configured for horizontal discharge and intake for supply and return air.
- C. Casing: Manufacturer's standard galvanized sheet metal construction with exterior enamel paint finish, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 2 inch-thick thermal insulation with solid galvanized steel liner, knockouts for electrical and piping connections, exterior condensate drain connection, and lifting lugs.
- D. Indoor Fan: Forward curved, centrifugal, direct driven, grease- lubricated ball bearings, and motor. Mount fan and motor assembly on base with spring isolators having 2-inch deflection.
1. Variable speed drive: refer to Division 23 Section 23 00 30 "Electrical Requirements for Mechanical Equipment" for drive requirements.
- E. Exhaust/Relief: Electric modulating damper.
- F. Return-Relief-Air Fan: Airfoil plug, centrifugal, direct driven, grease-lubricated ball bearings, and motor. Mount fan and motor assembly on base with spring isolators having 2-inch deflection.
1. Variable speed drive: refer to Division 23 Section 23 00 30 "Electrical Requirements for Mechanical Equipment" for drive requirements.
- G. Outside Coil Fan: Propeller type, directly driven by permanently lubricated motor.
- H. Refrigerant Coils: Aluminum-plate fin and seamless copper tube in galvanized-steel casing with equalizing-type vertical distributor and thermal expansion valve; tested to 450 psig and leak tested to 300 psig with air under water. Insulate coil section
- I. Compressors: Number as scheduled hermetic scroll compressors with integral vibration isolators, internal overcurrent and over-temperature protection, internal pressure relief, and crankcase heaters. Each unit shall have at least one variable speed compressor on one circuit and multiple compliant fixed speed scroll compressors on the other.
- J. Refrigeration System:
1. Compressors.
 2. Outside coil and fan.
 3. Indoor coil and fan.
 4. Check valves.
 5. Expansion valves with replaceable thermostatic elements.
 6. Refrigerant dryers.
 7. High-pressure switches.
 8. Low-pressure switches.
 9. Thermostats for coil freeze-up protection during low-ambient temperature operation or loss of air.
 10. Independent refrigerant circuits.
 11. Brass service valves installed in discharge and liquid lines.
 12. Charge of refrigerant.
 13. Timed Off Control: Automatic-reset control shuts compressor off after five minutes.
 14. Refrigerant Circuits: Interlaced refrigerant-coil circuiting with circuit for each compressor.
 15. Capacity Control: Cylinder unloaders with steps as scheduled.
 16. Compressor Motor Overload Protection: Manual reset.
 17. Antirecycling Timing Device: Prevents compressor restart for five minutes after shutdown.
 18. Adjustable, Low-Ambient, and Head-Pressure Control: Designed to operate at temperatures as low as 0 degrees F by cycling outside coil fans and controlling speed of last fan of each circuit.
 19. Oil-Pressure Switch: Designed to shut down compressors on low oil pressure.
- K. Pre-Filters: UL Class I, 4-inch-thick, high-efficiency, throwaway filters in filter rack; with 25 to 35 percent dust-

- spot efficiency (MERV 14) and 90 percent average arrestance.
- L. Heat Exchanger: Stainless steel construction for natural-gas-fired burners with the following controls:
 - 1. Redundant dual gas valve with manual shutoff.
 - 2. Fully modulating gas valve with turn-down ratio of at least 5:1.
 - 3. Direct-spark pilot ignition.
 - 4. Electronic flame sensor.
 - 5. Induced-draft blower.
 - 6. Flame rollout switch.
 - 7. Low limit switch.
 - M. Economizer: Return- and outside-air dampers with neoprene seals, outside-air filter, and hood.
 - 1. Damper Motor: Fully modulating spring return with adjustable minimum position.
 - 2. Control: Electronic-control system uses mixed-air temperature and selects between outside-air and return-air enthalpy to adjust mixing dampers.
 - 3. Relief Damper: Fully modulating spring return, controlled to maintain building pressure.
 - 4. Leakage: Maximum leakage 2.5 percent at nominal airflow of 400 cfm per ton with 1-inch w.g pressure differential.
 - N. Power Connection: 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. Refer to Division-26 for unit-mounted disconnect.
 - O. Unit Controls: Solid-state control board, display panel, and components contain at least the following features:
 - 1. Indoor fan on/off delay.
 - 2. Default control to ensure proper operation after power interruption.
 - 3. Service relay output.
 - 4. Unit diagnostics and diagnostic code storage.
 - 5. Field-adjustable control parameters.
 - 6. Economizer control and economizer fault detection.
 - 7. Minimum outside air flow set point.
 - 8. Outside air flow.
 - 9. Gas valve delay between first- and second-stage firing.
 - 10. Indoor-air quality control with carbon dioxide sensor.
 - 11. Low-ambient control, allowing operation down to 0 degrees F.
 - 12. Hot gas reheat coil control
 - 13. Minimum run time.
 - 14. Night setback mode.
 - 15. Return-air temperature limit.
 - 16. Smoke alarm with smoke detector installed in supply and return air.
 - 17. Low-refrigerant pressure control.
 - 18. Digital display of outside temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
 - 19. Variable-Air-Volume Control: Variable-frequency drive controls supply-air static pressure.
 - 20. Building pressure set point.
 - 21. Building pressure.
 - P. Control Interface: Install stand-alone control module providing BACnet link between unit controls and DDC temperature-control system.
 - Q. Temperature Control: Factory-installed, demand-oriented, solid-state microprocessor-based controller which will monitor and control the unit in a stand alone mode or as directed by a building automation system. Provide a minimum of two cooling steps and modulating heating control.
 - 1. The rooftop control panel will have a human interface panel with a clear English LCD display and keypad for monitoring, setting, editing and controlling.

2. The unit controls will perform the following control strategies:
 - a. Unoccupied Mode: The rooftop heating and cooling controls will modulate to maintain the discharge air temperature set point. Minimum outside air damper position will be zero percent open.
 - b. Night Setback: Maintain user-defined unoccupied heating and cooling set points. The outdoor air damper will remain closed for night setback operation (unless economizing for zone cooling). The fan will operate in the automatic control mode.
 - c. Purge/Night Economizer: The purge mode will turn on the fan and enable the economizer during unoccupied hours to cool a zone using cool outside air. Through Time of Day Scheduling, the operator will specify when the purge mode occurs. During the purge mode, the economizer will be enabled while mechanical outside cooling and heating are disabled.
 - d. Transition from Unoccupied to Occupied: When the unit transitions from the unoccupied operation to occupied operation, start-up or morning warm-up mode will be activated.
 - e. Startup Mode: During the Startup mode, heating and cooling are enabled for the Rooftop. On Variable Air Volume units, the transition from the Unoccupied to the Startup mode may initiate the Morning Warm-up mode, if the space temperature is below the Morning Warm-up set point. On both Constant Volume and Variable Air Volume units, the outside air damper will remain closed, unless economizing, until the zone's scheduled occupied time.
 - f. Morning Warm-up (CV and VAV Units): When the Rooftop changes from the Unoccupied to the occupied mode; the unit may enter the Morning Warm-up mode. The Morning Warm-up mode will be initiated if the Morning Warm-up sensor value is less than the Morning Warm-up set point. The economizer will be kept closed and the selected zone is heated. The Morning Warm-up set point will be based on one specific zone designated by the operator or based on an average zone temperature.
 - g. Occupied Operation: When the rooftop unit is controlled to the occupied mode, all rooftop unit functions will be enabled. Variable Air Volume units will operate in supply air temperature control mode, and Constant Volume units will operate under zone temperature control.
 - h. Cooling/Economizer: During the Occupied cooling mode of operation the economizer, if available, and mechanical cooling are used to control the zone temperature. If the enthalpy of the outside air is appropriate to use free cooling the economizer will be used to satisfy the zone temperature. If more cooling is then required, compressors will be staged on as necessary. Minimum On/Off timing of the compressors will prevent rapid cycling.
 - 1) At outdoor air conditions above the enthalpy control setting, mechanical cooling only will be used and the fresh air dampers will remain at, or return to minimum position.
 - i. Supply Air Set point (Variable Air Volume Units): The supply air set point for each rooftop unit will be defined by the user or reset automatically based on an outdoor air or zone temperature.
 - j. Burner: The burner will modulate to maintain the discharge air temperature set point.
 - k. Economizer Control (CV and VAV Units): If poor outdoor air conditions exist, the unit will lockout all economizers. On constant volume units, the controller will also set the minimum economizer position to maintain a minimum outdoor air flow (cfm). On VAV units, as the supply fan modulates down, the minimum economizer position will also be reset to compensate for the reduction in total airflow.
 - l. Timed Override: When a Timed Override is initiated by the user, the rooftop unit will return to its normal occupied mode for a period of time as specified at the unit. When the Timed Override period has ended, the unit will automatically return to its unoccupied cycle.
 - m. Space Pressure Control: (return/relief air fan) The space pressure control will modulate the relief damper/relief air fan to maintain the space pressure set point.
 - n. Supply Air Pressure Control (VAV Units): Modulate the variable speed drive based on the static pressure sensor located in the supply air duct. The microprocessor will also read the status on the supply air sensor and display the pressure reading on the status screen.
3. Diagnostic's and Alarms: Individual rooftop diagnostic and alarm statuses will include the following items

for each rooftop unit:

- a. Supply air temperature sensor failure.
 - b. Auxiliary temperature sensor failure.
 - c. Outdoor air temperature sensor failure.
 - d. Occupied zone cool/heat set point failure.
 - e. Supply air pressure sensor failure.
 - f. Outside air humidity sensor failure.
 - g. Evaporator temperature sensor failure (each circuit).
 - h. Condenser Temperature sensor failure (each circuit).
 - i. Morning warm-up zone sensor fail.
 - j. Heat failure.
 - k. Unoccupied zone cool/heat set point failure.
 - l. Supply air pressure set point failure.
 - m. Space static pressure set point failure.
 - n. Space pressure sensor failure.
 - o. Return air temperature sensor failure.
 - p. Return air humidity sensor failure.
 - q. Unit communications loss.
 - r. Heat communications failure.
 - s. Supply air temperature cool/heat set point fail.
 - t. Dirty filter.
 - u. Economizer fault.
- R. Optional Accessories:
1. Cottonwood Filter: Provide cottonwood filter as manufactured by Air Solution Company or prior approved equal for condenser coil protection.

2.2 ROOF CURBS

- A. 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. Thickness: 2 inches
 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.
- B. Curb Height: 14 inches.

2.3 VARIABLE SPEED DRIVES

- A. Refer to drawings for fan motors controlled by variable speed drives. Variable speed fan motor drives will be provided by the rooftop unit manufacture, and internally factory mounted in RTU for supply and return/relief fans.

- B. See Section 23 00 30 "Electrical Requirements for Mechanical Equipment" for requirements.

2.4 MOTORS

- A. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For HVAC Equipment".
- 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. Controllers, electrical devices, and wiring are specified in Division 26 Sections.

2.5 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."
- C. Fan Balancing: Fans shall be factory balanced and AMCA Certified to meet ANSI S2.19 grade G6.3 requirements. Filter-in vibration measurements shall not exceed 0.15 in/second peak at the fan RPM.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping, electric 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. Install units' level and plumb, maintaining manufacturer's recommended clearances.
- B. Curb Support: Install roof curb on roof structure, level and secure, according to NRCA's "Low- Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Conditioners and Ducts." Install and secure rooftop air conditioners on curbs and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
 - 1. Gas Piping: Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
 - 2. Cooling Coil Condensate Drain Piping: Install trap and extend condensate drain to the nearest roof drain unless indicated on the drawings.
- C. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general

arrangement of ducts. The following are specific connection requirements:

1. Connect supply and return ducts to rooftop unit with flexible duct connectors specified in Division 23 Section "Duct Accessories."
- D. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.
- E. Ground equipment according to Division 26 Section "Grounding and Bonding."
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field-testing. Report results in writing.
- B. Perform the following field quality-control tests and inspections and prepare test reports:
 1. After installing rooftop air conditioners 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. Remove malfunctioning units, replace with new units, and retest as specified above.

3.5 STARTUP SERVICE

- A. Engage a factory service representative to perform startup service. The service representative shall be trained at the factory for startup service.

3.6 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.7 DEMONSTRATION

- A. Provide services of manufacturer's technical representative for one (1) 8-hour day to instruct Owner's personnel in operation and maintenance of unit.
- B. Schedule training with Owner; provide at least seven (7) days' notice to Contractor and Engineer of training date.

END OF SECTION

SECTION 23 74 33 - DEDICATED OUTDOOR-AIR 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 factory-packaged units capable of supplying up to 100 percent outdoor air and providing cooling and heating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, 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. Prepare the following by or under the supervision of a qualified professional engineer:
 - a. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 - b. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For design of [vibration isolation] seismic restraints and wind restraints, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Unit fabrication and assembly details.
 - 2. 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.
 - 3. Design Calculations:
 - a. Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.
 - b. Indicate compliance with "Performance Requirements" article.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Roof-curb mounting 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. Size and location of unit-mounted rails and anchor points and methods for anchoring units to roof curb.
 - 2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.
- B. Startup service reports.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For units to include in emergency, 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. Filters: One set for each unit.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Five years from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: 25 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Trane.
 - 2. AAON.
 - 3. Munters Corporation.

2.2 PERFORMANCE REQUIREMENTS

- A. General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- B. n ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, seismic restraints and wind restraints.
- D. Cabinet Thermal Performance:
 - 1. Maximum Overall U-Value: Comply with requirements in ASHRAE/IESNA 90.1.
 - 2. Maximum Overall U-Value: 0.10 Btu/h x sq. ft. x deg F (0.57 W/sq. m x deg K).
 - 3. Include effects of metal-to-metal contact and thermal bridges in the calculations.
- E. Cabinet Surface Condensation:
 - 1. Cabinet shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior of the cabinet.
 - 2. Portions of cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casing to prevent condensation from occurring on the interior and exterior surfaces. The thermal break shall not compromise the structural integrity of the cabinet.
- F. Maximum Cabinet Leakage: 1 percent of the total supply-air flow at a pressure rating equal to the fan shut-off pressure.
- G. Cabinet Deflection Performance:
 - 1. Walls and roof deflection shall be within 1/240 of the span at the design working pressure equal to the fan shut-off pressure. Deflection limits shall be measured at any point on the surface.
 - 2. Floor deflections shall be within 1/240 of the span considering the worst-case condition caused by the following:
 - a. Service personnel.
 - b. Internal components.
 - c. Design working pressure defined for the walls and roof.
- H. 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.

2.3 CABINET

- A. Construction: Double wall.
- B. Exterior Casing Material: Galvanized steel with baked enamel finish or stainless steel.
- C. Interior Casing Material: Galvanized or stainless steel.

- D. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.
- E. Base Rails: Galvanized-steel rails for mounting on roof curb or pad as indicated.
- F. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 - 1. Service Doors: Hinged access doors with gaskets. Material and construction of doors shall match material and construction of cabinet in which doors are installed.
- G. Roof: Standing seam or membrane; sloped to drain water.
- H. Floor: Reinforced, metal surface; reinforced to limit deflection when walked on by service personnel. Insulation shall be below metal walking surface.
- I. Cabinet Insulation:
 - 1. Type: Fibrous-glass duct lining complying with ASTM C 1071, Type II
 - 2. Thickness: 2 inches (50 mm).
 - 3. Insulation Adhesive: Comply with ASTM C 916, Type I.
 - 4. Mechanical Fasteners: Suitable for adhesive, mechanical, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.
- J. Condensate Drain Pans:
 - 1. Shape: Rectangular, with 2 percent slope in at least two planes to direct water toward drain connection.
 - 2. Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.
 - a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - b. Depth: A minimum of 2 inches (50 mm) deep.
 - 3. Configuration: Double wall, with space between walls filled with foam insulation and moisture-tight seal.
 - 4. Material: Stainless-steel sheet.
 - 5. Drain Connection:
 - a. Located on both ends of pan, at lowest point of pan.
 - b. Terminated with threaded nipple.
 - c. Minimum Connection Size: NPS 1 (DN 25).
 - 6. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- K. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.
- L. Roof Curb: Full-perimeter curb of sheet metal, minimum 16 inches (400 mm) high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
 - 1. Comply with requirements in "The NRCA Roofing Manual."

2.4 SUPPLY FAN

- A. Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.
 - 1. Fan Wheel Material: Aluminum; attached directly to motor shaft.
 - 2. Fan Wheel Drive and Arrangement: Direct drive, AMCA Arrangement 4.
 - 3. Fan panel and frame Material: Powder-coated steel, stainless steel, or aluminum.
 - 4. Fan Enclosure: Easily removable enclosure around rotating parts.
 - 5. Fan Balance: Precision balance fan below 0.08 inch/s (2.0 mm/s) at design speed with filter in.
- B. Motors:
 - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 2. Enclosure: Open dripproof.
 - 3. Efficiency: Premium efficient.
 - 4. Service Factor: 1.15.
- C. Mounting: Fan wheel, motor, and drives shall be mounted to fan casing with spring isolators.

2.5 POWER EXHAUST

- A. Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.
 - 1. Fan Wheel Material: Aluminum; attached directly to motor shaft.
 - 2. Fan Wheel Drive and Arrangement: Direct drive, AMCA Arrangement 4.
 - 3. Fan panel and frame Material: Powder-coated steel, stainless steel, or aluminum.
 - 4. Fan Enclosure: Easily removable enclosure around rotating parts.
 - 5. Fan Balance: Precision balance fan below 0.08 inch/s (2.0 mm/s) at design speed with filter in.
- B. Motors:
 - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 2. Enclosure: Open dripproof.
 - 3. Efficiency: Premium efficient.
 - 4. Service Factor: 1.15.

2.6 ENERGY RECOVERY (ERV)

- A. Casing:
 - 1. Galvanized steel to prevent corrosion.
 - 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 (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
 - 3. Casing seals on periphery of rotor and on duct divider and purge section.
 - 4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing.

B. Rotor:

1. Media shall be made of aluminum, formed into a honeycomb structure to minimize pressure loss and avoid plugging.
2. Media must be coated to resist corrosion. All surfaces must be coated with a non-migrating desiccant layer to insure that adequate latent capacity is provided. The desiccant coating must be firmly bonded to the aluminum surface and will not be dislodged when challenged with high velocity air up to 5000 feet per minute.
3. The cassette must be a slide out design for serviceability. The media shall be cleanable with low temperature steam, hot water or light detergent without degrading the latent recovery.
4. Sensible and latent recovery efficiencies must be clearly documented through a testing program conducted in accordance with ASHRAE Standard 84 and AHRI 1060.
5. The energy wheel shall operate effectively up to 180 degrees F.
6. The rotor media shall be permanent, with an anticipated life of 20 years. It must be tested in accordance with ASTM Standard E-84 and provide smoke and flame spread ratings of less than 25 and 50 as required by NFPA 90A and UL 1995. A copy of the ASTM E-84 test report confirming the method of test and results shall be provided with the submittal. Heat recovery wheels incorporating "throw-away" media and tested to UL900 for Class 2 filters are not acceptable.

2.7 Supplied with perimeter brush seals and face contact seals to minimize air leakage and wheel bypass.COOLING COILS

- A. Capacity Ratings: Comply with ASHRAE 33 and ARI 410 and coil bearing the ARI label.
- B. Coil Casing Material: Stainless steel.
- C. Tube Material: Copper.
- D. Tube Header Material: Manufacturer's standard material.
- E. Fin Material: Aluminum.
- F. Fin and Tube Joints: Mechanical bond.
- G. Leak Test: Coils shall be leak tested with air underwater.
- H. Refrigerant Coil Capacity Reduction: Circuit coils for face control.
- I. Refrigerant Coil Suction and Distributor Header Materials: Seamless copper tube with brazed joints.
- J. Coating: Corrosion-resistant coating after assembly.

2.8 REFRIGERATION SYSTEM

- A. Comply with requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."
- B. Refrigerant Charge: Factory charged with refrigerant and filled with oil.
- C. Compressors: Scroll compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater.

D. Refrigerant: R-410A.

1. Classified as Safety Group A1 according to ASHRAE 34.
2. Provide unit with operating charge of refrigerant.

E. Refrigeration System Specialties:

1. Expansion valve with replaceable thermostatic element.
2. Refrigerant dryer.
3. High-pressure switch.
4. Low-pressure switch.
5. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
6. Brass service valves installed in discharge and liquid lines.

F. Capacity Control:

1. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.
2. Patented, Rawal APR control with zero to 100 percent modulating capacity control using hot-gas bypass. Evaporator coil shall be continuously active for dehumidification.
3. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
4. 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.

G. Refrigerant condenser and reheat condenser coils:

1. Capacity Ratings: Complying with ASHRAE 33 and ARI 410 and coil bearing the ARI label.
2. Tube Material: Copper.
3. Fin Material: Aluminum.
4. Fin and Tube Joint: Mechanical bond.
5. Leak Test: Coils shall be leak tested with air underwater.
6. Coating: Corrosion-resistant coating after assembly.

H. Condenser Fan Assembly:

1. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades.
2. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Motor Enclosure: Totally enclosed non-ventilating (TENV) or totally enclosed air over (TEAO) enclosure.
 - c. Built-in overcurrent and thermal-overload protection.
 - d. Efficiency: Premium efficient.
 - e. Service Factor: 1.4.
3. Fan Safety Guards: Steel with corrosion-resistant coating.

I. Safety Controls:

1. Compressor motor and condenser coil fan motor low ambient lockout.
2. Overcurrent protection for compressor motor.
 - a.

2.9 INDIRECT-FIRED GAS FURNACE HEATING

A. Furnace Assembly:

1. Factory assembled, piped, and wired.
2. Comply with requirements in NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
3. AGA Approval: Designed and certified by and bearing label of AGA.

B. Burners:

1. Heat-Exchanger Material: Stainless steel with a minimum thermal efficiency of 80 percent.
2. Fuel: Natural gas.
3. Rated for a turndown ratio of at least 10:1.
4. Ignition: Electronically controlled electric spark with flame sensor.

C. Heat-Exchanger Drain Pan Material: Stainless steel.

D. Venting: Gravity vented.

E. Venting: Power vent with integral, motorized centrifugal fan interlocked with gas valve.

F. Safety Controls:

1. Gas Control Valve: Electronic modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.10 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.11 FILTERS

A. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.

2. Factory-fabricated, dry, extended-surface type.
3. Thickness: 2 inches (50 mm).
4. Minimum MERV: 8, according to ASHRAE 52.2.
5. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.

B. 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. Extended surface 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.

2.12 ELECTRICAL POWER CONNECTIONS

- A. General Electrical Power Connection Requirements: 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 shall be to NEMA KS 1, heavy-duty, nonfused 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 according to IEC 60947-4-1.
 2. NEMA KS 1, heavy-duty, nonfusible 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.
- J. Lights: Factory wire unit-mounted lights.
- K. Receptacle: Factory wire unit-mounted, ground fault interrupt (GFI) duplex receptacle.
- L. Control Relays: Auxiliary and adjustable time-delay relays.

2.13 CONTROLS

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- 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-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.
 - i. Space differential pressure sensor.
- E. Control Dampers:
 - 1. Damper Location: Factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification.
 - 2. Damper Leakage: Comply with requirements in AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. (33 L/s per sq. m) at a static-pressure differential of 4.0 inches water column (1000 Pa) when a torque of 5 inch pounds per sq. ft. (30.1 Newton meters per sq. m) is applied to the damper jackshaft.
 - 3. Damper Rating: Rated for close-off pressure equal to the fan shutoff pressure.
 - 4. Damper Label: Bear the AMCA seal for both air leakage and performance.
 - 5. Blade Configuration: Unless otherwise indicated, use parallel blade configuration for two-position control and equipment isolation service and use modulating control when mixing two airstreams. For other applications, use an opposed-blade configuration.
 - 6. Damper Frame Material: Extruded aluminum or stainless steel.
 - 7. Blade Type: hollow-shaped airfoil.
 - 8. Blade Material: Extruded aluminum or stainless steel.

9. Maximum Blade Width: 6 inches (150 mm).
10. Maximum Blade Length: 48 inches (1200 mm).
11. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression-type seals.
12. Bearings: Thrust bearings for vertical blade axles.
13. Airflow Measurement:
 - a. Monitoring System: Complete and functioning system of airflow monitoring as an integral part of the damper assembly where indicated.
 - b. Remote Monitoring Signal: 0-10 volt or 4-20 mA scaled signal.
 - c. Accuracy of flow measurement: Within 5 percent of the actual flow rate between the range of the scheduled minimum and maximum airflow. For units with a large range between minimum and maximum airflow, configure the damper sections and flow measurement assembly as necessary to comply with accuracy.
 - d. Straightening Device: Integral to the flow measurement assembly if required to achieve the specified accuracy as installed.
 - e. Flow measuring device: Suitable for operation in untreated and unfiltered outdoor air. If necessary, include temperature and altitude compensation and correction to maintain the accuracy.

F. Damper Operators:

1. Factory-installed electric operator for each damper assembly with one operator for each damper assembly mounted to the damper frame.
2. Operator capable of shutoff against fan pressure and able to operate the damper with sufficient reserve power to achieve smooth modulating action and proper speed of response at the velocity and pressure conditions to which the damper is subjected.
3. Maximum Operating Time: Open or close damper 90 degrees in 60 seconds.
4. Adjustable Stops: For both maximum and minimum positions.
5. Position Indicator and Graduated Scale: Factory installed on each actuator with words "OPEN" and "CLOSED," or similar identification, at travel limits.
6. Spring-return operator to fail-safe; either closed or open as required by application.
7. Operator Type: Direct coupled, designed for minimum 60,000 full-stroke cycles at rated torque.
8. Position feedback Signal: For remote monitoring of damper position.
9. Coupling: V-bolt and V-shaped, toothed cradle.
10. Circuitry: Electronic overload or digital rotation-sensing circuitry.

G. Refrigeration System Controls:

1. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb (65 kJ/kg) of dry air or outdoor-air temperature is less than 60 deg F (15 deg C).

H. Furnace Controls:

1. Retain first subparagraph below for discharge sensing.
2. Factory-mounted sensor in supply outlet with sensor adjustment located in control panel to modulate gas furnace burner to maintain discharge temperature.
3. Remote Setback: Adjustable room thermostat selected by timer, set at 50 deg F (10 deg C); cycles supply fan and gas furnace burner to maintain space temperature.
4. Staged Burner Control: Four steps of control.

5. Electromechanical or Electronic Burner Control: 20 to 100 percent modulation of the firing rate; 10 to 100 percent with dual-furnace units.
 - I. Integral Smoke Alarm: Smoke detector installed in supply air.
 - J. 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 operating.
 - d. Furnace operating.
 - e. Constant and variable motor loads.
 - f. Variable-frequency-controller operation.
 - g. Cooling load.
 - h. Economizer cycles.
 - i. Air-distribution static pressure and ventilation-air volumes.
 - K. 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, space temperature set-point adjustment space pressure set-point adjustment.
 2. ASHRAE 135 (BACnet) 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.
 3. ailable through the DDC system for HVAC.
- 2.14 ACCESSORIES
- A. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.
 - B. Duplex Receptacle: Factory mounted in unit supply-fan section and refrigeration section, with 20 amp 120 V GFI duplex receptacle and weatherproof cover.

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 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

- A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.
- B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."
 - 1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
 - 2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
 - 3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.
- C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."
- D. Equipment Mounting:
 - 1. Install air units on vibration isolation curb.
 - 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."
- E. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- 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. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."
- H. Install separate devices furnished by manufacturer and not factory installed.

- I. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- J. Install drain pipes from unit drain pans to sanitary drain.
 - 1. Drain Piping: Drawn-temper copper water tubing complying with ASTM B 88, Type L (ASTM B 88M, Type B), with soldered joints.
 - 2. Drain Piping: Schedule 40 PVC pipe complying with ASTM D 1785, with solvent-welded fittings.
 - 3. Pipe Size: Same size as condensate drain pan connection.

3.3 CONNECTIONS

- A. Where installing piping adjacent to units, allow space for service and maintenance.
- B. Gas Piping Connections:
 - 1. Comply with requirements in Section 231123 "Facility Natural-Gas Piping."
 - 2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
 - 3. Install AGA-approved flexible connectors.
- C. Hydronic Piping Connections:
 - 1. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - 2. Install shutoff valve and union or flange on each supply connection and install balancing valve and union or flange on each return connection.
- D. 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."
- E. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.
 - 1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Inspect units for visible damage to furnace combustion chamber.
 - 3. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.

- c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-limit heat exchanger.
 - b. Alarms.
5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. 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.
7. 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.
8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.

- b. Return-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.

3.5 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.

3.6 DEMONSTRATION

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

END OF SECTION 237433

SECTION 23 81 29 - 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, delegated design and the following components to make a complete operating system(s) according to requirements indicated:

1. Recessed, ceiling-mounted (360 cassette) indoor units.
2. Exposed, wall-mounted indoor units.
3. Under ceiling/wall indoor units.
4. Under ceiling indoor units.
5. Recessed, 4-way ceiling cassette indoor units.
6. Mini 4-way ceiling cassette indoor units.
7. Recessed, slim 1-way ceiling cassette indoor units.
8. Concealed, ceiling-mounted, ducted indoor units Up to 23,999 BTU/Hr.
9. Concealed, ceiling-mounted, ducted indoor units, Between 24,000 and 53,999 BTU/Hr.
10. Concealed, ceiling-mounted, ducted indoor units 54,000 BTU/Hr and Over.
11. Concealed, ceiling-mounted, slim, ducted indoor units.
12. Cased, floor-standing, indoor units.
13. Concealed, floor-standing, indoor units.
14. Indoor, hydronic heat exchangers.
15. Indoor, hydronic heat-pump units.
16. Indoor, hydronic heat recovery units.
17. Outdoor, air-source heat-pump units.
18. Outdoor, air-source heat recovery units.
19. Mode control units for heat recovery systems.
20. Electronic expansion valve kits for multi-zone heat pump systems.
21. Electronic expansion valve kits for single zone heat pump systems and heat recovery systems.
22. System controls.
23. System refrigerant and oil.
24. System refrigerant piping.
25. Metal hangers and supports.
26. Metal framing systems.
27. Fastener systems.
28. Miscellaneous support materials.
29. Piping and tubing insulation.
30. System control cable and raceways.

1.3 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. EEPROM: Electrically erasable programmable read-only memory.
- C. Electronic Expansion Valve (EEV): EEV's are used in heat pump and heat recovery systems.
- D. Heat Pump (HP) 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.
- E. Heat Recovery (HR) System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
- F. HSP: High static pressure.
- G. Mode Control Unit (MCU): MCU's are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones.
- H. MSP: Medium static pressure.
- I. 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.
- J. OAP: Outside air processing.
- K. PCB: Printed circuit board.
- L. 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.
- M. 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 MCUs. One liquid line and refrigerant vapor line connect MCUs to associated indoor units.
- N. 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.
 - 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 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 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. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

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.

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. Source quality-control reports.

D. Field quality-control reports.

E. 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. Service and installation manuals must be readily available on the manufacturer's website without entering a username and password.
- 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.
 2. Controllers for Indoor Units:
 - a. One for each unique controller type installed.

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.

B. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. In-place facility located within 100 miles of Project.
3. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.
5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. 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. The installing contractor shall have attended VRF HVAC system manufacturer's installation training prior to installing the system.
4. Retain copies of Installer certificates on-site and make available on request.
5. 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.
6. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

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.
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: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Trane split system heat pump with hyper-heating, or a comparable product by one of the following:

1. Carrier Corporation; a unit of United Technologies Corp.
2. Daikin AC (Americas), Inc.
3. Fujitec America, Inc.
4. LG Electronics.
5. Mitsubishi Electric & Electronics USA, Inc.

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. MCUs.
4. EEVs.
5. Refrigerant isolation valves.
6. 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, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
 - 1. Two-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 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 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. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.
 1. Each branch circuit shall accommodate addition of one indoor unit(s) with unit capacity equal to largest indoor unit connected to the branch circuit.
- E. Isolation of Equipment: Provide isolation valves to isolate each indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.
- F. 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 50 percent.
 2. Not more than 130 percent.
 3. Range acceptable to manufacturer.
- G. System Turndown: Stable operation down to 16 percent of outdoor-unit capacity.
- H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.
- I. Outdoor Conditions:
 1. Suitable for outdoor ambient conditions encountered.

- a. Design equipment and supports to withstand wind loads of governing code and ASCE/SEI 7.
 - b. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7.
 - c. 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.
 - J. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
 - 1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
 - 2. Outdoor Unit – Heat Pump: Outdoor air-source heat pump units (individual modules) shall have a sound rating no higher than 64 dBA.
 - K. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
 - L. Capacities and Characteristics: As indicated on Drawings.
- 2.4 CONCEALED, CEILING-MOUNTED, DUCTED INDOOR UNIT
- 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: Galvanized 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 from three sides.
 - C. DX Coil Assembly:
 - 1. Construction: Nonferrous construction, smooth plate fins on copper tubing.
 - 2. Coil Tubes: Copper with internal grooves.
 - 3. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 4. Internal Tubing: Copper tubing with brazed joints.
 - 5. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 6. Field Piping Connections: Manufacturer's standard.
 - 7. Factory Charge: Dehydrated air or nitrogen.
 - 8. Testing: Factory pressure tested and verified to be without leaks.
 - 9. Refrigerant Piping: Insulate both refrigerant lines to the indoor unit in accordance with the manufacturer's recommendations.
 - D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted condensate pump with check valve, with a maximum vertical lift of 29 inches.
3. Condensate Float Switch: Disable unit operation in the event of condensate overflow.
4. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan: Two Sirocco fans direct-driven by a single motor, statically and dynamically balanced.
2. Construction: Fabricated from non-ferrous components.
3. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Three speed settings with a speed range of least 50 percent.
6. Static Pressure Scanning: The indoor unit shall have static pressure scanning for simple setup and optimized comfort settings for the occupant.
7. Smart Tuning: The indoor unit shall have smart-tuning function that can provide optimized comfort by allowing the occupant to offset the fan airflow curve with a wired remote controller to increase or decrease airflow.
8. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Return Air Filter: Manufacturer's standard included on return air inlet.
2. Return Air Filter Box Accessory: Side access, for angle filter orientation, to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
3. Efficiency: ASHRAE 52.2, MERV 7.
 - a. Replaceable: Extended surface panel filter.

G. 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.

H. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. EEPROM: Removable EEPROM on PCB stores all system data, programming information, unit name, serial number, and other data.
3. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, filter service notification, drain assembly high water level safety shutdown and notification.
4. Factory-Installed Sensors: Discharge air temperature.
5. Remote Controller: Fan speed adjustable with accessory remote controller, or service software, according to external static pressure.
6. Supplemental Heat: External heater control programming capability for supplemental heat via external contact control module, requires an accessory PCB.
7. Room Occupancy Control: External contact control module for unoccupied room control functions, requires an accessory PCB.
8. Communication: Network communication with other indoor units and outdoor unit(s).
9. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

10. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls, 208/230 V, single phase, 60 hertz.
3. Disconnecting Means: Circuit breaker or switch.
4. Control Transformer: Manufacturer's standard, factory installed.
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.

2.5 OUTDOOR, AIR-SOURCE HEAT PUMP 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 either all heating or all cooling demands, but not 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. The sum of the connected capacity of all indoor units shall range from 50 to 130 percent of outdoor nominal capacity.
4. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have a total refrigerant tubing length of 984 feet. The greatest length is not to exceed 492 feet between the outdoor unit and the indoor units without the need for line size changes or traps.
5. The outdoor unit shall have rated performance for heat operation at -13°F ambient temperature without additional low ambient controls. The unit shall maintain 100% heat output at 0°F without a supplemental heat source or a second compressor to boost low ambient heating performance.
6. The outdoor unit shall be capable of operating in cooling mode down to 0°F with optional manufacturer supplied low ambient kit. Manufacturer supplied low ambient kit shall be provided with predesigned control box rated for outdoor installation and capable of controlling kit operation automatically in all outdoor unit operation modes. Manufacturer supplied low ambient kit shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
7. Manufacturer supplied low ambient kit shall be factory tested in low ambient temperature chamber to ensure operation. Factory performance testing data shall be available when requested.
8. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel, bonderized, with a powder coated baked enamel finish.
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.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, inverter driven, direct vapor injected, asymmetric, hermetically sealed scroll compressor(s) with a turndown to 16 percent of rated capacity. Fixed capacity compressors are not acceptable.
2. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. Thermal and overload.
 - c. Voltage fluctuations.
 - d. Phase failure and phase reversal.
 - e. Short cycling.
3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Current Limit Control: Systems shall have current limit control from 50 to 100 percent of design current. Current limit is adjustable at outdoor unit or at central web accessible control devices.
6. Temperature Calibration: Systems shall allow adjustment of target evaporator coil temperatures in cooling mode, and target heating discharge pressures, depending on project conditions, for heating and cooling calibration to reduce energy use.
7. Accumulator: Systems shall have an accumulator with accumulator return valve control.
8. Defrost Cycle Logic: Systems shall have defrost cycle logic to reduce defrost cycle frequency by monitoring air resistance across the condenser coil during heating operation to determine defrost operation initiation and prevent unnecessary defrost cycles.
9. Oil Recovery Cycle Logic: Systems shall have an advanced oil recovery cycle logic operation that does not interrupt heating or cooling operation. The oil recovery cycle duration shall not exceed 3 minutes while in cooling mode or 6 minutes while in heating mode. While in heat mode, any defrost cycle lasting over 3 minutes shall be considered an oil recovery cycle.
10. Oil Separator: Systems shall have high efficiency, individual oil separator(s) for each compressor plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
11. Subcooler: Systems shall have a flat-plate type subcooler to subcool liquid refrigerant to increase capacity and performance with long pipe lengths, and to decrease refrigerant sound at indoor equipment.
12. Protection: Systems shall have a high pressure safety switch, high voltage fuses, over-current protection, phase detection protection, thermal fan protection, low pressure protection, compressor overcurrent protection, fan motor voltage protection, current transformer(s), crankcase heaters, and intelligent logic to ensure proper operation within unit design limitations and operational parameters.
13. Flash Injection: The compressors shall have flash injection capability to increase performance in both heating mode. This will be automatically enabled by the outdoor unit(s) by forcing saturated refrigerant vapor and liquid mixture directly into the scroll compression cycle increasing mass flow and overall system capacity. Compressors without flash injection are not acceptable.
14. Refrigerant Cooled PCB's: Inverter-driven compressor PCB(s) shall be cooled with liquid refrigerant circuit(s) to operate at optimal temperatures and to prevent failure due to overheating. No compressor inverter PCB's shall be cooled by air over heat sink. Cooling inverter components without air-cooling fins prevents failure due to environmental contaminants.
15. Oil management system to ensure safe and proper lubrication over entire operating range.
16. Crankcase heaters with integral control to maintain safe operating temperature.

D. 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.
 - d. Protection: Integral metal guard.
2. Corrosion Protection: Coating with documented salt spray test performance of 2000 hours according ASTM B 117 surface scratch test (SST) procedure.
3. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.
 - a. Vertical discharge airflow.
 - b. Direct-drive arrangement.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - d. 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 15 percent.
6. Fan Ducting: Condenser fans shall have the capability for ducting of discharge air up to 0.32-in. wg (79.6 Pa) static pressure with factory provided dimensional design drawings. Units shall not require any field installed components or component modification to allow ducting of discharge air.
7. Vibration Control: Integral isolation to dampen vibration transmission.

F. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Removable EPROM: The heat pump outdoor unit shall have a removable EEPROM at the main PCB to store all unit data. All data on the outdoor unit EEPROM shall be viewable from the manufacturer provided service software. The outdoor unit main EEPROM shall be removable allowing replacement of outdoor unit PCB without losing digital, field programmed data. The outdoor unit removable EEPROM shall store the following unit data: unit model number, unit serial number, unit main PCB firmware and MICOM version, sub-PCB firmware and MICOM version, fan PCB firmware and MICOM version, inverter PCB 1 and inverter PCB 2 firmware and MICOM version, auto-trial commissioning startup data, the last 30 minutes of operation data, and field programmed unit name/tag viewable on controls and service software.
4. Capacitor Discharge: The heat pump outdoor unit shall have the ability to discharge inverter PCB capacitor voltage using service buttons on the outdoor unit main PCB. The capacitor stored-voltage discharge feature shall allow safe inverter PCB replacement.
5. Compressor Disable: The heat pump outdoor unit shall allow temporary disabling of individual compressors to allow system operation at reduced capacity after a compressor or compressor

component related issue (when more than one compressor is present in system). Disabling of a compressor shall temporarily remove error codes and allow system operation.

6. Compressor Frequency, Heating: To reduce energy use, the heat pump outdoor unit shall have the capability to reduce compressor frequency (heating mode capacity) when the average indoor unit room temperature is 3.6 deg F less than the setpoint temperature.
7. Compressor Frequency, Cooling: To reduce energy use, the heat pump outdoor unit shall have the capability to reduce compressor frequency (cooling mode capacity) when average indoor unit setpoint temperature is 3.6 deg F less than the room temperature.
8. Compressor Soft-Start: The heat pump outdoor unit compressors shall have a soft-start function to reduce electricity demand during system start and to increase compressor reliability.
9. Error Codes: In the event of system error due to outdoor unit failure, the heat pump outdoor unit shall display codes that specify a precise error and which outdoor unit PCB is the cause.
10. Condenser Fan Snow Clearing: Systems shall have a snow blowing setting to prevent snow accumulation on top of unit at fan discharge. Setting is field enabled by installer.
11. Factory-Installed Sensors:
 - a. Refrigerant suction temperature.
 - b. Refrigerant discharge temperature.
 - c. Outdoor air temperature.
 - d. Refrigerant high pressure.
 - e. Refrigerant low pressure.
 - f. Sub-cooler inlet and outlet refrigerant temperature.
 - g. Compressor top temperature sensor(s).
12. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, night setback control, power consumption display, run test switch equalize run time between multiple same components.
13. Communication: Network communication with indoor units and other outdoor unit(s).
14. Auto-Addressing: The heat pump system shall support system auto-addressing allowing system commissioning without manually configuring indoor unit addresses.
15. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
16. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

G. 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: Circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard.
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.

H. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for 2000 hours according ASTM B 117.

I. 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.

2.6 SYSTEM CONTROLS

A. General Requirements:

1. The VRF control system shall consist of remote controllers, system controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The control system shall support operation monitoring, scheduling, error monitor, power distribution, personal browsers, tenant billing, online maintenance support, and integration with Building Automation Systems (BAS) using BACnet interfaces
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 and change of value notifications.
4. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Contractor-furnished PC connected to central controller(s).
 - 3) Web interface through web browser software.
 - 4) Integration with Building Automation System.
 - b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:
 - 1) On/off control.
 - 2) Temperature set-point adjustment.

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 or Spanish.
10. Supports Imperial and Metric Temperature Units: Fahrenheit and 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 and percent capacity.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
 - a. Include multiple interconnected controllers as required.
2. 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.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - a. Sets schedule for daily, weekly, and annual events.
 - b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.
4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures and percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.

12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.
13. Integration to BACnet Building Automation System (BAS)

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English Spanish.
4. Temperature Units: Fahrenheit and Celsius.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments .
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments.
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter".
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

E. Wireless Controllers for Indoor Units:

1. Wireless Communication:
 - a. Controller communicates to remote-mounted receiver that is wired to indoor unit(s).
 - 1) Include receivers with wireless controllers as required to complete installation.
 - 2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.
 - b. One wireless controller shall be capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.
2. Controller Battery Life: Three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Multiple Language: English or Spanish.

5. Temperature Units: Fahrenheit and Celsius.
6. On/Off: Turns indoor unit on or off.
7. Hold: Hold operation settings until hold is released.
8. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
9. Temperature Display: 1-degree increments.
10. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments.
11. Relative Humidity Display: 1 percent increments.
12. Relative Humidity Set-Point: Adjustable in 1 percent increments.
13. Fan Speed Setting: Select between available options furnished with the unit.
14. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
15. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
16. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
17. Occupancy detection.
18. Service Notification Display: "Filter".
19. Service Run Tests: Limit use by service personnel to troubleshoot operation.
20. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
21. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
22. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

2.7 HEAT RECOVERY UNIT (HRU)

A. General

1. HR unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
2. HR unit casing shall be made with galvanized steel.
3. HR unit shall require 208-230V/1-phase/60Hz power supply.
4. HR Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems simultaneous cooling and heating operation.
5. HR unit shall be engineered to work with a three pipe VRF system comprising of
 - a. High Pressure Vapor Pipe
 - b. Low Pressure Vapor Pipe
 - c. Liquid Pipe
6. HR unit shall be designed to be piped in series or parallel.
7. HR unit shall have 2, 3 or 4 ports.
 - a. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.
 - b. Each port shall be capable of connecting from 1 to 8 indoor units to a maximum nominal capacity of 54MBh.
 - c. Maximum nominal capacity per HR unit shall not exceed 192MBh.
 - d. Indoor units greater than 54MBh nominal capacity shall be twinned using a reverse Y-branch.
8. HR unit shall be internally piped, wired, assembled and run tested at the factory.
9. HR unit shall be designed for installation in a conditioned environment.
10. HR unit shall have a liquid bypass valve.
11. HR unit shall have (2) two-position solenoid valves per port.

12. HR unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching.
13. HR unit shall have an electronic expansion valve for subcooling.
14. HR unit shall not require a condensate drain.
15. HR unit shall be internally insulated.
16. All field refrigerant lines between outdoor unit and HR unit and from HR unit to indoor unit shall be field insulated.
17. The HR unit shall not exceed a net weight of 49 lbs.
18. The system shall be designed to accommodate 16 HR units connected to Heat Recovery units piped in single series string.
19. A single series pipe string of 1 to 16 HR units shall be capable of serving indoor units with a total nominal capacity of 192 MBH per HR unit.

B. Piping Capabilities

1. The elevation difference between indoor units on heat pump systems shall be 131 feet.
2. The elevation differences for heat recovery systems shall be:
 - a. Heat recovery unit (HRU) to connected indoor unit shall be 49 feet
 - b. HRU to HRU shall be 49 feet
 - c. Indoor unit to indoor unit connected to same HRU shall be 49 feet
 - d. Indoor unit to indoor unit connected to separate parallel HRU's shall be 131 feet.
 - e. The acceptable elevation difference between two series connected HR units shall be 16 feet.

C. Controls

1. HR unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.
2. HR unit shall communicate with the air source unit via the air source/indoor unit 2-conductor shielded communications cable terminated using a daisy chain configuration.

- D. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat Recovery unit to allow the servicing of HR units refrigerant circuit or the replacement of HR unit without evacuating the balance of the piping system.

2.8 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. Refrigerant: A full charge of R-410A is included only for the condensing unit by VRF HVAC system manufacturer. Provide additional refrigerant based on diameters and lengths of system liquid refrigerant lines, and indoor equipment model and quantity.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.9 SYSTEM HYDRONIC PIPING

- A. Comply with requirements in Section 232113 "Hydronic Piping" for system piping requirements.

2.10 SYSTEM REFRIGERANT PIPING

- A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.
- B. 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.
 - 1. Y-Joint Fittings: Piping to multiple indoor units requires additional piping components. Use VRF HVAC system manufacturer's Y-joint fittings to branch the main refrigerant lines.
 - 2. Tee Fittings: VRF HVAC system manufacturer's tee fittings must be used to connect outdoor units when multiple module systems are being installed (systems with more than one outdoor unit).
- C. Refrigerant Isolation Ball Valves:
 - 1. 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.
 - 2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
 - 3. Valve Connections: Flare or sweat depending on size.

2.11 METAL HANGERS AND SUPPORTS

- A. Copper Tube 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 galvanized or copper-coated steel.
- B. Plastic Pipe Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.
 - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

2.12 METAL FRAMING SYSTEMS

- A. MFMA Manufacturer Metal Framing Systems:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Thomas & Betts Corporation; A Member of the ABB Group.
 - c. Unistrut; Part of Atkore International.
 - 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 galvanized steel for use indoors and of stainless steel for use outdoors.
7. Metallic Coating for Use Indoors: Electroplated zinc.
8. Plastic Coating for Use Outdoors: epoxy or polyester.

2.13 FASTENER SYSTEMS

- A. 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.
- B. 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.
 1. Indoor Applications: stainless steel.
 2. Outdoor Applications: Stainless steel.

2.14 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- B. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.
- C. 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.

2.15 PIPING AND TUBING INSULATION

- A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.
- B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:
 1. Flexible Elastomeric Insulation:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C 534, Type I for tubular materials.
 - b. Indoors: 1/2 inch (13 mm) thick.
 - c. Outdoors: 1 inch (25 mm) thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: PVC, color selected by Architect, 20 mils (0.5 mm) thick.
- c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch (0.51 mm) thick.

C. Refrigerant Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

- a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C 534, Type I for tubular materials.
- b. Indoors: 1 inch (25 mm) thick.
- c. Outdoors: 1 inch (25 mm) thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: PVC, color selected by Architect, 20 mils (0.5 mm) thick.
- c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch (0.51 mm) thick.

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

- 1. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. PVC Jacket Adhesive: Compatible with PVC jacket.

- 1. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

F. Metal Jacket Flashing Sealants:

- 1. Materials shall be compatible with insulation materials, jackets, and substrates.
- 2. Fire- and water-resistant, flexible, elastomeric sealant.
- 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 4. Color: Aluminum.
- 5. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.16 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

- 1. 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.
 - a. Flame Travel Distance: 60 inches (1520 mm) or less.
 - b. Peak Optical Smoke Density: 0.5 or less.

- c. Average Optical Smoke Density: 0.15 or less.
 - 2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
 - 3. 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.
- B. Low-Voltage Control Cabling:
- 1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
 - 2. Lead Content: Less than 300 parts per million.
 - 3. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.
 - 4. Lead Content: Less than 300 parts per million.
- C. TIA-485A Network Cabling:
- 1. Standard Cable: NFPA 70, Type CMG.
 - a. Paired, one pair, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
 - 2. Lead Content: Less than 300 parts per million.
 - 3. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: NFPA 262.

4. Lead Content: Less than 300 parts per million.
- D. Ethernet Network Cabling: TIA-568-C.2 Category 6a cable with RJ-45 connectors.
1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
 2. Conductors: 100-ohm, 23 AWG solid copper.
 3. Lead Content: Less than 300 parts per million.
 4. Shielding: Shielded twisted pairs (FTP).
 5. Cable Rating: By application.
 6. Jacket: Yellow thermoplastic.
- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.17 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
- B. Equipment will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports for historical record. Submit reports only if requested.

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 products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

- A. Clearance:
 - 1. Maintain manufacturer's recommended clearances for service and maintenance.
 - 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 - 1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.
- C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF INDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. 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 (10 mm).
- C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
- D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch (13 mm).
- H. Attachment: Install hardware for proper attachment to supported equipment.
- I. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Install outdoor units on support structures indicated on Drawings.
- C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 2. Grouting: Place grout under equipment supports and make bearing surface smooth.
- D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- A. 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.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.
- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
- K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

- A. General Requirements for Drain Piping and Tubing:
 1. Install a union in piping at each threaded unit connection.
 2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
 3. 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:

- a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
 4. 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.
 5. 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.
- B. Gravity Drains:
1. Slope piping from unit connection toward drain termination at a constant slope of not less than two percent.
- C. Pumped Drains:
1. 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.

3.7 INSTALLATION OF HYDRONIC PIPING

- A. Comply with requirements for hydronic pipe and tubing specified in Section 232113 "Hydronic Piping."
- B. Comply with requirements for hydronic specialties specified in Section 232116 "Hydronic Piping Specialties."
- C. Install continuous-thread hanger rods and spring hangers of size required to support equipment weight.
1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC." Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- D. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

3.8 INSTALLATION OF REFRIGERANT PIPING

- A. Refrigerant Tubing Kits:
1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
 2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet (1.5 m). Minimum rod size, 1/4 inch (6.4 mm).
 3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.
- B. Install refrigerant piping according to ASHRAE 15 and governing codes.

- C. Select system components with pressure rating equal to or greater than system operating pressure.
- D. Install piping as short and direct as possible, with a minimum number of joints and fittings.
- E. 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.
- F. Install refrigerant piping and tubing in protective conduit where installed belowground.
- G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
- H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
 - 1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- I. When brazing, remove or protect components that could be damaged by heat.
- J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- K. Joint Construction:
 - 1. Ream ends of tubes and remove burrs.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 - 3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.9 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- B. 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.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- E. Fastener System Installation:

1. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) 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.
 3. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. 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.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel.
1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. 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.
- L. Piping and Tubing Insulation:
1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 2. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
- M. Horizontal-Piping Hangers and Supports: 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 (DN 15 to DN 750).
 2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
 5. Pipe stands for horizontal pipes located outdoors.
 6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- N. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
1. Sizes through NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
- O. Plastic Pipe Hanger and Support Spacing:
1. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
 2. Maximum spacing, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
- P. Vertical-Piping Clamps: Install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.
- Q. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 feet (1.5 m).
- R. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- S. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- T. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- U. Trim excess length of continuous-thread hanger and support rods to 1 inch (25 mm).
- V. Hanger-Rod Attachments: Install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- W. Building Attachments: 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. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. 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 (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.10 INSTALLATION OF PIPING AND TUBING INSULATION

- A. 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.
- B. Insulation Installation on Pipe Fittings and Elbows:
 1. Install mitered sections of pipe insulation.
 2. 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.
- C. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. 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.
 3. 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.
- D. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- E. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.11 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

- A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
- B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
- C. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
- D. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."

3.12 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. 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.
1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch (13 mm) high.
 2. Locate nameplate or label where easily visible.
- G. 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.

1. Outlet boxes for cables shall be no smaller than 4 inches (102 mm) square by 2-1/8 inches (53 mm) deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
 2. Flexible metal conduit shall not be used.
- H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- I. Install manufactured conduit sweeps and long-radius elbows if possible.
- J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.13 SOFTWARE

A. Cybersecurity:

1. Software:
 - a. Coordinate security requirements with IT department.
 - b. Ensure that latest stable software release is installed and properly operating.
 - c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.
2. Hardware:
 - a. Coordinate location and access requirements with IT department.
 - b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
 - c. Disable dual network connections.

3.14 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:
 - a. Within equipment and associated control enclosures.
 - b. In accessible ceiling spaces where open cable installation method may be used.
2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.

5. 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.
6. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. 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.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch (13 mm) at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 30 inches (760 mm) apart.
2. 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.

F. 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.

3.15 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.16 GROUNDING INSTALLATION

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.17 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.18 FIELD QUALITY CONTROL

- A. 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.
 - 1. Field service shall be performed by an employee or 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.
 - a. 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.
 - 2. Kick-off Meeting:
 - a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
 - b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
 - c. Meeting shall cover the following as a minimum requirement:
 - 1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
 - 2) Manufacturer's installation requirements specific to systems being installed.
 - 3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
 - 4) Required field activities related installation of VRF HVAC system.

- 5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.
3. Final Inspection before Startup:
- a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
 - b. 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.
 - c. 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.
 - d. 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.
 - e. 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.

f. 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.

g. 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.

h. Inspection reports for hydronic 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) Condensate removal acceptable.
- 16) Noise level within an acceptable range.
- 17) Refrigerant piping properly connected and insulated.
- 18) Hydronic piping properly connected and insulated.
- 19) Proof of water flow checked for proper operation.
- 20) Condensate drain piping properly connected and insulated.
- 21) If applicable, external interlocks properly connected.
- 22) 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.
- B. Perform the following tests and inspections with the assistance of manufacturer's service representative:
 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. Leak Test: After installation, charge system 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. Refrigerant Tubing Positive Pressure Testing:
 1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
 2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.2 times VRF HVAC system operating pressure, but not less than 600 psig (4137 kPa), using dry nitrogen.
 3. 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.
 4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
 5. Submit test reports for Project record.
- D. Refrigerant Tubing Evacuation Testing:
 1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
 2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
 3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
 4. Prepare test report to record the following information for each test:

- a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
5. Submit test reports for Project record.
 6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.19 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be an employee or a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.
6. .

C. 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.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.20 ADJUSTING

- A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.
- D. 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.

3.21 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. 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.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.22 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.

3.23 DEMONSTRATION

- A. 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.
- B. Instructor:
 - 1. 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.
 - 2. Instructor's credentials shall be submitted for review by Owner before scheduling training.
 - 3. Instructor(s) sole job responsibility shall be Owner training.
 - 4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.
- C. Schedule and Duration:
 - 1. Schedule training with Owner at least 20 business days before first training session.
 - 2. Training shall occur before Owner occupancy.
 - 3. Training shall be held at mutually agreed date and time during normal business hours.
 - 4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
 - 5. Perform not less than 16 total hours of training.
- D. Location: Owner shall provide a suitable on-site location to host classroom training.
- E. Training Attendees: Assume eight people.
- 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.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain Commissioning Agent or Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 238129

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 23 82 39.19 - WALL AND CEILING UNIT HEATERS

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 wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include details of anchorages and attachments to structure and to supported equipment.
 - 4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 5. Wiring Diagrams: Power, signal, and control wiring.
- C. Samples: For each exposed product and for each color and texture specified.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berko; Marley Engineered Products.
 - 2. INDEECO.

3. Markel Products; TPI Corporation.
4. Marley Engineered Products.
5. QMark; Marley Engineered Products.
6. Trane.

2.2 DESCRIPTION

- A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
- 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.

2.3 CABINET

- A. Front Panel: Extruded-aluminum bar grille, with removable panels fastened with tamperproof fasteners.
- B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

- A. Fan: Aluminum propeller directly connected to motor.
- B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

- A. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit.
- B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Install wall and ceiling unit heaters to comply with NFPA 90A.
- B. Install wall and ceiling unit heaters level and plumb.
- C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 26 01 26 - TESTING ELECTRICAL SYSTEM

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Applicable provisions of Division 00 and Division 01 shall govern work under this section.

1.2 SCOPE

- A. Prior to energizing equipment, perform inspections and acceptance tests as herein specified.
- B. Assure that electrical equipment is operational within industry and manufacturer's tolerances and is installed in accordance with design specifications.
- C. Infrared scan all feeder and circuit connections and terminations in all existing panelboards being reused in remodeling areas. See Part 3 – Execution.
- D. Perform testing as specified in other sections of Division 26.

1.3 ITEMS TO BE TESTED

- A. Panelboards
- B. Feeders
- C. Grounding
- D. Circuit Breakers

1.4 RELATED WORK

- A. Section 26 05 26 – Grounding
- B. Section 26 24 16 – Panelboards
- C. Section 26 27 26 – Wiring Devices
- D. Section 26 28 13 – Fuses
- E. Section 26 28 16 - Enclosed Switches and Circuit Breakers

1.5 QUALITY ASSURANCE

- A. Comply with the requirements of the following regulatory agencies;
 - 1. National Fire Protection Association (NFPA), Chapter 70 National Electrical Code (NEC).
 - 2. Underwriters' Laboratories, Inc. (UL).
- B. Conform to the standards of the following agencies;

1. National Electrical Manufacturer's Association (NEMA)
 2. American Society for Testing and Materials (ASTM)
 3. Institute of Electrical and Electronic Engineers (IEEE)
 4. National Electrical Testing Association (NETA)
 5. Insulated Power Cable Engineers Association (IPCEA)
- C. Inspections and tests shall utilize the following references:
1. Project design specifications.
 2. Project design drawings.
 3. Manufacturer's instruction manuals applicable to each particular apparatus.

1.6 TEST REPORT SUBMITTALS

- A. Five (5) copies of complete testing report on a CDs in pdf format.
- B. Submit report no later than 30-days after completion of testing.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 GENERAL

- A. Test work and equipment installed to ensure its proper and safe operation in accordance with intent of drawings and specifications.
- B. Check interlocking and automatic control sequences and test operation of safety and protective devices.
- C. Correct defects.
- D. Cooperate with electrical utility, suppliers, and manufacturer's representatives in order to achieve proper and intended operation of equipment.
- E. Test, adjust and record operating voltages at each system level before energizing branch circuits.
- F. Replace devices and equipment damaged due to failure to comply with this requirement

3.2 GROUNDING

- A. Refer to Section 26 05 26 for grounding test.

3.3 CIRCUIT BREAKERS

- A. Perform a visual inspection of all new and existing circuit breakers being reused. Specifically examine as follows:
 - 1. Exercise each circuit breaker to verify proper operation. Verify opening and closing with the use of an ohm meter
 - 2. Physically examine each circuit breaker case for signs of checking, cracking, tracking on surfaces or signs of excess heat.
 - 3. Perform insulation resistance test on all new circuit breakers to assure no current can flow outside of its intended path. Measure insulation resistance between inner and outer poles and between outer poles.
 - 4. Measure the contact resistance of each new circuit breaker.
 - 5. Replace all circuit breakers that are not within the manufacturer's acceptable limits of measurement for insulation resistance and contact resistance.
 - 6. Provide a report of test results indicating the test date, who performed testing, the designation of the distribution panel or main distribution panel what tested, whether it passed or failed, and what steps were or will be taken to remediate circuit breakers which failed testing.

3.4 PANELBOARDS

- A. All field tests for panelboards as herein outlined shall be completed by the Electrical Contractor.
- B. Measure steady state load currents at each panelboard branch circuit; rearrange circuits in the panelboard if required to balance the phase loads to within 7-1/2 percent to each other.
- C. Visual and mechanical inspection
 - 1. Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.
 - 2. Megger check of phase-to-phase and phase-to-ground insulation levels prior to connection of any load circuits.
 - 3. Test results shall be submitted to the Owner and Engineer in a standard format.

3.5 FEEDERS

- A. All field tests for feeders as herein outlined shall be completed by the Electrical Contractor.
- B. Each feeder shall be megger tested for insulation resistance.
- C. Test results shall be submitted to the Owner and Engineer in a standard format.
- D. Torque all lugs on terminations per manufacturer's recommendation.

3.6 INFRA-RED SCANNING

- A. Infra-red scan shall be performed by third party testing company of all utilized existing panelboards three (3) months after occupancy and one (1) year after occupancy to confirm tightness of connections and terminations.
- B. Scan feeder connections, load circuit connections and circuit breakers.
- C. Provide a report and photos indicating the results of the infra-red scans. The report shall indicate trouble spots and the time, date and actions taken to remediate a high each condition where excess temperatures were encountered.

END OF SECTION 26 01 23

SECTION 26 05 00 - GENERAL ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.01 RELATED REQUIREMENTS

- A. Applicable provisions of Division 0 and Division 1 shall govern Work under this Section.

1.02 WORK INCLUDED IN THE ELECTRICAL CONTRACT

- A. The mention of any Article, operation or method requires that the Contractor shall provide same and perform each operation in complete accordance with the conditions stated. The Contractor shall provide all material, labor, equipment and transportation as necessary to complete the project in compliance with the Contract Documents. In general, this work includes everything essential for a complete electrical system in operating order as shown on the drawings and indicated in the specifications.
- B. All work shall be installed in accordance with all State and Local Inspection Authorities having jurisdiction together with the recommendations of the manufacturer whose equipment is to be supplied and installed under this Contract.
- C. Before submitting a bid, each bidder shall examine the drawings relating to their work and shall become fully informed as to the extent and character of the work required and its relation to other work in the building.
- D. The Contractor, in conjunction with the Architect's representative, shall establish exact locations of all materials and equipment to be installed. Consideration shall be given to construction features, equipment of other trades and requirements of the equipment proper.
- E. All materials shall be suitably stored and protected prior to installation and all work shall be protected after installation, during construction and prior to acceptance.
- F. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for delivery, erection and installation of all equipment and apparatus required to be installed by the Contractor. All such equipment shall be removed by the Contractor upon completion of the project.
- G. Refer to General Requirement for temporary electrical service.

1.03 DEFINITIONS

- A. The Owner. The individual who the Owner selects as the project representative.
- B. The Architect. Bailey Edward, 35E Wacker Dr, Suite 2800, Chicago IL 60601
- C. The Engineer. RTM Engineering Consultants, LLC. 250 S Wacker dr, Suite 400, Chicago IL 60606.
- D. This Contractor. The Electrical Contractor, also referred to as "The Contractor".
- E. Provide. Furnish, install and wire complete and ready for service.
- F. Exposed. Exposed to view in any room, corridor or stairway.
- G. Code. National, State and Local Electrical codes including OSHA requirements.

- H. Equals. Manufacturers or methods listed by name in the specifications, on the drawings or in an addendum are considered to be equals.
- I. Substitution. Any manufacturer or method other than those listed by name in these specifications, on the drawings, or in an addendum.
- J. Signal Voltage. NEC class 1, 2, or 3 remote control, signaling, or power limited circuits.
- K. Low Voltage. 50 to 600 volts.
- L. Medium Voltage. 601 to 35,000 volts.
- M. High Voltage. 35,001 volts and greater.
- N. Electrical Ductbank. Assembly consisting of electrical conduits encased in concrete.

1.04 ABBREVIATIONS

- A. A/E: Architect and/or Engineer
- B. ENGR: Engineer
- C. NEC: National Electrical Code
- D. NEMA: National Electrical Manufacturer's Association
- E. NFPA: National Fire Protection Association
- F. OSHA: Occupational Safety and Health Administration
- G. UL: Underwriter's Laboratories

1.05 PERMITS AND LICENSES

- A. The Contractor shall prepare and submit all applications and working drawings, as required, to authorities having jurisdiction over the project. All licenses and permits required shall be secured and paid for by the Contractor.

1.06 STANDARDS AND CODES

- A. All work shall be installed in accordance with National, State, and Local codes, ordinances, laws, and regulations. Comply with all applicable OSHA regulations.
- B. All materials shall have a UL or ETL label where a UL or ETL Standard and/or test exist.

1.07 DIMENSIONS AND DEFINITE LOCATIONS

- A. The drawings depicting electric work are diagrammatic and show, in their approximate location, symbols representing electrical equipment and devices. The exact location of such equipment and devices shall be established in the field in accordance with instructions from the Architect and/or as established by manufacturer's installation drawings and details.
- B. The Contractor shall refer to shop drawings and submittal drawings for all equipment requiring electrical connections to verify rough-in and connection locations.
- C. Unless specifically stated to the contrary, no measurement of an electric drawing derived by scaling shall be used as a dimension to work by. Dimensions noted on the electric drawings are subject to measurements of adjacent and previously completed work. All measurements shall be performed prior to the actual installation of equipment.

1.08 DRAWINGS

- A. The Contractor shall keep a detailed up-to-date record, of the manner and location in which all installations are actually made, indexing each feeder, pull box and protective device. Upon

completion of the project, the contractor shall modify the project electronic drawings in AutoCAD and Revit MEP, and specification files to incorporate this information. Modified documents shall be turned over to the Owner in both electronic and hard paper copy formats. Record drawings shall also include:

1. Locations of all buried conduit or similar items. Include buried depth.
 2. Field changes of dimension or detail.
 3. Changes made by field order or change order.
 4. Details not on original contract drawings.
 5. Changes to circuit numbers.
 6. Junction box locations and conduit runs, with trade sizes indicated, for all lighting, power, and electrical systems installed.
 7. As Built Drawings - See General Requirements - Division 1.
- B. In the event of a conflict between the drawings and specifications, this Contractor shall base their bid on the greater quantity, cost or quality of the item in question, unless such conflict is resolved by an addendum.

1.09 MATERIALS AND EQUIPMENT

- A. All materials and equipment required shall be new.
- B. All equipment supplied shall be based on materials and equipment of manufacturers specified. No substitutions will be allowed except as permitted in this specification.
- C. All items specified shall be the latest type or model produced by the manufacturer specified. If descriptive specification or model number is obsolete, substitute the current product.

1.10 SUBSTITUTIONS

- A. Substitutions shall not be allowed. In any case where the Contractor wishes to use equipment or methods other than those listed by name, that equipment must be approved by the Engineer. To gain approval for equipment not listed, the Contractor shall submit the following to the Engineer for his review.
 1. Documentation from the equipment manufacturer indicating where this equipment meets and does not meet the specifications or drawings as written. This documentation shall state all exceptions taken to the specification and the reasons for such exceptions. All documentation relative to the request shall be submitted on the manufacturer's letterhead and signed by a representative of the manufacturer.
 2. Manufacturer's Cut Sheets: Provide manufacturers cut sheets with complete model number in PDF format for review.
 3. Lighting Fixtures: Request for substitutions shall include photometric test reports performed by an independent testing laboratory.
 4. The Contractor shall provide samples of the proposed equipment for the Engineer's review, if requested by the Engineer.

5. The Contractor shall furnish any other information or materials as requested by the Architect/Engineer to establish equality.
- B. The Contractor shall acknowledge that they have reviewed the submission criteria for the request by stamping the submission with a review stamp or acknowledgement by an accompanying letter.
- C. Equipment and materials submitted for review without proper documentation will be rejected without review.
- D. Any submittal, including samples, shall be received in the Engineer's office 5 days prior to bidding. Equipment will only be approved "as equal" if there is adequate time to issue an addendum to notify all bidders of the approval.
- E. Materials, equipment, or methods of installation other than those named, will be accepted only if such articles are in accordance with the general requirements and are similar in composition, dimension, construction, capacity, finish and performance.
- F. Contractors submitting equipment for approval as an equal, shall include in their bids all incidental costs that may result from the use of approved equipment. Such costs shall include, but not be limited to, additional costs that may be incurred by other contractors whose scope of work is affected by use of the "equal" product. The Electrical Contractor shall be responsible for those costs even if they do not become evident until after bidding.

1.11 SHOP DRAWINGS AND EQUIPMENT BROCHURES

- A. Submit to Engineer for review, the manufacturer's shop drawings and/or equipment brochures in PDF format
- B. Shop drawings shall be submitted in advance of construction and installation so as to not cause delay in other Contractor's work.
- C. All data submitted for Engineer's review shall be numbered consecutively, shall be noted to correlate with the electrical drawings and shall bear:
 1. The name and location of the project.
 2. The name of the Contractor.
 3. The date of submittal.
 4. The date of the drawings and the date of each correction and revision.
- D. If more than one type of lighting fixture (or other material) is on a submitted PDF, the proposed equipment shall be conspicuously highlighted or noted by the Electrical Contractor.
- E. Shop drawings for different systems and equipment shall be combined into a separate PDF by specification section and not by manufacturer. Submittals which contain different specification section systems combined into one PDF will be returned for resubmittal.
- F. Lighting Fixture shop drawings shall consist of a single submittal with all project light fixtures included. Submittals grouped by manufacturer shall not be accepted. The contractor shall be responsible for coordinating drawings from his various suppliers in order to comply with this requirement.

- G. The Contractor shall approve shop drawings and equipment brochures prior to submission. The Contractor shall verify that the materials and equipment depicted will properly fit into the construction. The Contractor shall also review all previously completed work related to the installation of the equipment depicted to insure that it has been properly installed.
- H. Materials or equipment subject to prior review by the Engineer shall not be fabricated or installed by the Contractor, without approval. The Engineer's review of shop drawings shall not relieve the Contractor of responsibility for deviations from the requirements of the drawings and specifications, unless prior approval for such deviations has been granted.

1.12 MAINTENANCE MANUALS

- A. The Electrical Contractor shall assemble and submit to the Architect for subsequent submission to the Owner, three complete sets of a Manual of Operation and Maintenance for each of the electrical and communications systems.
- B. Each manual shall consist of a loose leaf bound volume instructing the Owner's personnel in the use, operation and maintenance of the system in question. The manual shall cover all phases of operation of the equipment and shall be illustrated with photographs, drawings, wiring diagrams, etc. Manuals shall accurately describe the operation, construction and adjustable features of the complete system and its component parts. The manual shall be complete with an equipment parts listing to facilitate the ordering of spare and replacement parts.
- C. The engineer will give consideration to maintenance manuals being provided on computer compact discs with maintenance manual files stored in a PDF format. If this is desired, the contractor shall provide a written request prior to submitting the manuals indicating which equipment manuals they propose to provide in this format.
- D. Each manual shall contain two sets of final shop drawings depicting equipment as installed.

1.13 CLEANING AND PAINTING

- A. All rubbish resulting from this work shall be removed and disposed of on a daily basis in such manner as to be acceptable to the Architect.
- B. The Contractor shall clean all exposed iron work, the interior and exterior of cabinets and pull boxes, etc., and remove all rubbish and debris resulting from the work.
- C. Where painted surfaces of equipment have been damaged or rusted during construction, the Contractor shall paint same to match final.
- D. Clean other equipment as indicated in other sections of the specification for specific equipment.

1.14 TESTS AND ACCEPTANCE

- A. The operation of the equipment and electrical systems does not constitute an acceptance of the work by the Owner. The final acceptance is to be made after the Contractor has adjusted his equipment and demonstrated that it fulfills the requirements of the drawings and the specifications.
- B. After the work is completed and prior to acceptance, the Contractor shall conduct the following tests, tabulate data, date, sign and submit to the Engineer:
 - 1. Standard megger insulation test on each feeder.
 - 2. Ground resistance test.

3. Clamp ammeter test on each feeder conductor with all utilization equipment energized. The load current in each phase conductor of the feeder or the portion thereof supplying the panel shall not differ from the average connected load currents in the feeder conductors by more than 7½%. If the load current does differ by more than 7½%, the Contractor shall change phase loading to same or receive written approval from the Engineer that this is not required due to the nature of the load.
- C. Upon completion of the installation, the Contractor shall furnish certificates of approval from all authorities having jurisdiction. The Contractor shall demonstrate that all work is complete and in perfect operating condition, with race way and conduit system properly grounded, all wiring free from grounds, shorts, and that the entire installation is free from any physical defects.
- D. In the presence of the Engineer and the Owner, the Contractor shall demonstrate the proper operation of all miscellaneous systems.
- E. Perform other test as specifically directed in other sections of the specification for specific equipment.

1.15 GUARANTEE

- A. See General Conditions.

1.16 IDENTIFICATION

- A. Each distribution and lighting panel shall be equipped with an electronically printed directory describing the loads served. Directory shall be contained in a steel frame mounted on the inside face of the panel's door and shall be covered with a sheet of clear plastic.
- B. Panels and cabinets shall be provided with 1/8" minimum thickness 5 ply lamecoid plastic nameplates indicating usage, plan designation and voltage where applicable. For Switchboards, transfer switches, transformers and panel boards label shall include branch, voltage, phase, ampere rating, power source designation and source room location. Refer to specification 26 24 16 for panel labels. In Equipment and Mechanical Rooms this identification may be on the exterior of the unit, in other areas identification shall be inside the door or cover. Nameplates shall be black with white engraved lettering. Lettering shall be ½" high minimum. Fasten nameplates with escutcheon pins.
- C. Junction and pullboxes smaller than 12" X 12" shall be identified by using a permanent marker on the coverplate indicating originating panelboard and circuit(s) or system served.
- D. Junction and pull boxes with dimensions 12" X 12" and larger shall be stenciled or provided with permanent labels as follows:
 1. Lighting and power feeders and branch circuits - 120, 208, 277, 480. Add "EM" for emergency circuits, ex. 120EM, etc.
 2. Voice/Data communications - V/D COM
 3. Fire Alarm - FA
 4. Signal voltage lighting controls - LVLC
 5. Card Access System - CA
- E. Branch wiring shall be color coded per industry standards. Where wires of different systems junction in a common box each cable shall be grouped with its own system and identified using tags or identification strips.

- F. On all 3-phase systems, each phase shall be identified at all terminals using code markers.
- G. All cover plates for control stations controlling remote equipment shall be engraved to identify the device being controlled.
- H. All motor starters, remote control stations, etc., shall be identified with engraved lamecoid nameplates fastened to the equipment with escutcheon pins. Nameplates shall be 1/8" 5 ply lamecoid with 1/4" white letters on a black background. Adhesive cloth labels, similar to those manufactured by Brady Label Co., may be used on motor switches and controls only, indicating the number, designation, size and usage of the motor.
- I. On the OUTSIDE of coverplates for light switches, occupancy sensors, receptacles, and special purpose outlets, provide a permanent label identifying the panel and circuit number feeding the device. Clear adhesive plastic tape with black lettering will be permitted for this use.
- J. On light fixtures at the wiring entrance point, provide a permanent label identifying the panel and circuit number feeding the fixture. Adhesive plastic tape will be permitted for this use.
- K. Refer to individual specification sections for more specific or additional identification requirements.

1.17 ACCESS PANELS

- A. All access panels required by code or otherwise to electrical service equipment shall be supplied and installed by Electrical Contractor.

1.18 SPARE PARTS

- A. Requirements for spare parts are outlines in individual specification sections. Spare parts shall be turned over, unopened, to the Owner as part of the maintenance manual submittal.

1.19 PREBID SURVEY

- A. Before submitting his bid the Contractor shall tour the job site to review the following:
 - 1. The exact configuration of areas requiring demolition, temporary power, relocating, etc.
 - 2. Site conditions such as material storage, staging areas, parking, etc.
 - 3. Problems with work sequence.
- B. Any conditions found that are not shown on the documents but that may affect the scope of the work shall be reported to the Engineer.

PART 2 - PRODUCTS

2.01 FIRESTOPPING

- A. Refer to Division 7 for fire stopping requirements.

2.02 SLEEVES

- A. Schedule 40 galvanized steel pipe.

2.03 ACCESS PANELS

- A. Access panels shall be of size required to provide adequate access to equipment. Minimum size shall be 12" X 12" for hand access or 24" X 24" for body access.
- B. Panels shall be as manufactured by Milcor or equivalent.

- C. Panels shall include concealed hinges, cam type locking devices, and shall have a frame border type necessary for the particular wall or ceiling construction in which they are installed. Access panels shall be flush mounted, recessed frame type units. Access panels shall be prime coated steel, suitable for field painting for general applications and stainless steel for use in toilet rooms, shower rooms, and similar wet locations.
- D. Refer to architectural room finish schedule for wall and ceiling surfaces and finishes.
- E. Panel construction shall be as follows:
 - 1. Minimum 16 gauge frame, not less than 18 gauge hinged door panel. Door locks shall be screwdriver operated for panels in general location applications and shall be key locked for public area applications.

PART 3 - EXECUTION

3.01 FIRE STOPPING

- A. Refer to division 7 for fire stopping requirements.
- B. Openings in fire rated construction and annular spaces around conduits, cable trays, and other penetrating items shall be protected in accordance with NEC article 300-21. The fire rating of the protective seal shall be at least that of the floor or wall into which it is installed, so that the original fire rating of the construction is maintained.
- C. All wall or floor penetrations openings shall be as small as possible.
- D. All openings and annular spaces required by code to be protected shall be protected whether specifically indicated on the plans or not.
- E. Installation of materials and assemblies shall be in strict accordance with the manufacturer's instructions.

3.02 SLEEVES

- A. Where conduits, cables trays, or other electrical raceways must pass through floors or walls that are to be constructed of poured in place concrete, the contractor shall provide sleeves in the formwork prior to the concrete pour. For low voltage systems Hilt speed sleeves shall be provided. It shall be the Electrical Contractor's responsibility to provide all sleeves for his work unless specifically indicated otherwise on the plans. Prior to installing the sleeves the contractor shall prepare drawings indicating the locations, quantities, sizes, and spacings of all sleeves anticipated. The drawings shall be forwarded to the structural engineer for approval.
- B. Floor sleeves shall extend a minimum of 2 inches above the finished floor.

END OF SECTION 26 05 00

SECTION 26 05 01 - ELECTRICAL DEMOLITION AND ALTERATIONS

PART 1 - GENERAL

1.01 RELATED REQUIREMENTS

- A. Applicable requirements of Division 00 and Division 01 shall govern work in this section.

1.02 JOB CONDITIONS

- A. The existing building shall remain in service during construction. Power outages and interruptions in building systems shall be held to a minimum and shall be done at a time convenient to the Owner. The time of all outages shall be scheduled with the Owner and all other trades affected by the outage at least ten working days in advance. All demolition work shall be scheduled at periods and times acceptable to the Owner.
- B. Refer to Division 02 - Existing Conditions for areas and equipment being remodeled.
- C. Prior to demolition or alteration of structures, the following shall be accomplished:
 - 1. Owner release of such structure.
 - 2. Disconnection of electrical power to equipment and circuits removed or affected by demolition work.
 - 3. Electrical services rerouted or shut off outside area of demolition.
 - 4. Coordinate sequencing with Owner and other Contractors.
 - 5. Survey and record condition of existing facilities to remain in place that may be affected by demolition operations. After demolition operations are completed, survey conditions again and restore existing facilities to their predemolition condition.
- D. Contractor shall dispose of all obsolete material.
- E. Contractor shall notify the Engineer of any existing code violations observed during the course of performing his work. The Engineer will decide if corrective action needs to be taken. Corrective actions that change the scope of the work will be considered a change order and will be processed accordingly.

PART 3 - EXECUTION

3.01 MODIFICATIONS

- A. Feeders, branch circuits, and other system wiring which are to remain in service but which are presently routed through areas being demolished shall be rerouted around demolition area.

3.02 REMOVAL

- A. Electrical equipment in conflict with construction shall be removed or relocated as indicated on drawings, as directed, or required.
- B. Remove or relocate conduit, wire, boxes, fixtures that are in the way of construction.
- C. Reconnect circuits and equipment to be continued in service.

- D. Provide temporary wiring to any equipment that is to remain in operation during demolition and whose power would be interrupted as a result of demolition.
- E. Remove electrical equipment released from service as a result of construction or as indicated on drawings.
- F. Do not reuse removed electrical equipment except as specifically directed on the drawings.
- G. Where the plans require existing equipment to be removed or relocated, removal shall include all equipment associated with the device. Associated equipment shall include but not be limited to coverplates, backboxes, conduit, fittings, de-energized conductors, etc. In instances where a device is removed but active conductors remain in the backbox and the box is mounted in a wall which is remaining, the backbox may remain and a blank coverplate provided. If removal of the box is specifically indicated on the plans the active conductors shall be intercepted at convenient, accessible locations and rerouted to allow existing box to be removed. When boxes are removed from existing walls which will remain, it shall be the Electrical Contractor's responsibility to fill in openings and sand as required flush with adjacent surfaces. The General Contractor shall be responsible for final finish work unless specifically indicated otherwise on the plans.

3.03 DISPOSAL

- A. Dispose of equipment that is removed unless specifically indicated on the drawings.
- B. Raceway, conductors, boxes, cabinets and supporting devices shall become the property of the Contractor and shall be removed from the site and disposed of by the Contractor.
- C. The Contractor shall tour demolition areas with the Owner to determine the status of all other equipment to be removed during demolition. All equipment that is to be salvaged for reuse by the Owner shall be removed by the Contractor and transported to an owner designated storage area on the site. The Owner shall be responsible for removal of salvaged equipment from the storage area.
- D. Contractor, at his option, may install new conductors in existing raceways provided that the raceways are in place and are properly sized and supported. Existing conduits that are removed from their existing location shall not be reinstalled.

3.04 LIGHTING FIXTURE LAMP DISPOSAL

- A. The Contractor shall be responsible for the proper removal and recycling of all existing fixture lamps being removed from service in accordance with EPA and State of Illinois DNR requirements. Lamps shall not be disposed of in any way except as described herein.
- B. The Contractor shall be responsible for arranging for recycling of lamps by a licensed waste lamp and bulb recycler. The cost for recycling of removed lamps shall be included in the Contractor's bid.
- C. The Contractor shall carefully package removed lamps to prevent breakage. The Contractor shall store waste lamps in a secure area, either in the container that the lamps are shipped in or in other ways so as to eliminate breakage. Both the lamp storage area and individual containers should be labeled as hazardous waste. Store lamps in covered containers to prevent lamps from being broken as a result of other debris being placed on top of them.

3.05 ALTERATIONS

- A. The Contractor shall be responsible for work of other trades to facilitate installation of electrical work in the existing building.

- B. Work required by Electrical Contractor which is normally performed by other trades shall be done under direction and at the expense of Electrical Contractor.

END OF SECTION 26 05 01

SECTION 26 05 19 - 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. Copper building wire rated 600 V or less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

- A. PV: Photovoltaic.
- B. RoHS: Restriction of Hazardous Substances.
- C. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

2.2 FIRE-ALARM WIRE AND CABLE

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, as recommended by system manufacturer.
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.

2.3 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

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.
- C. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- B. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

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.
 - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) 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 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."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- 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 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 of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
- E. Cables will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports 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.

END OF SECTION 26 05 19

SECTION 26 05 26 - 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.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Ground rods.
 - 2. Grounding arrangements and connections for separately derived systems.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

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. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 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 (6 mm) 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 (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 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. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel[, sectional type]; 3/4 inch by 10 feet (19 mm by 3 m)

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. 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 (50 mm) minimum from wall, 6 inches (150 mm) 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.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
- C. 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.
- D. 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.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches (50 mm) 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. Use exothermic welds for all below-grade connections.
 - 3. For grounding electrode system, install at least [three] <Insert number> 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 (18 m) apart.
- G. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- 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. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. 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 Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
- G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

SECTION 26 05 29 - 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. Steel slotted support systems.
 - 2. Conduit and cable support devices.
 - 3. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum ~~13/32-inch-~~ (10-mm-) diameter holes at a maximum of ~~8 inches~~ (200 mm) o.c. in at least one surface.
 - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 2. Material for Channel, Fittings, and Accessories: Galvanized steel.
 - 3. Channel Width: Selected for applicable load criteria.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. 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.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
3. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125/F 3125M, **Grade A325** (**Grade A325M**).
4. Toggle Bolts: All-steel springhead type.
5. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA 1.
 2. NECA 101
 3. NECA 102.
 4. NECA 105.
 5. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. 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** (**100 mm**) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than **4 inches** (**100 mm**) thick.
 6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69] [Spring-tension clamps.
 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.
- C. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. 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.

3.4 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 (0.05 mm).

END OF SECTION 26 05 29

SECTION 26 05 33 - 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 and fittings.
 - 2. Boxes, enclosures, and cabinets.
- B. Related Requirements:
 - 1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of conduit groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with ANSI C80.1 and UL 6.
3. ARC: Comply with ANSI C80.5 and UL 6A.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
6. EMT: Comply with ANSI C80.3 and UL 797.
7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
5. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.

- C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, Type FD, with gasketed cover.
- D. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- F. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

- G. Gangable boxes are allowed.
- H. 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.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: GRC.
 - 2. Concealed Conduit, Aboveground: GRC.
 - 3. Underground Conduit: RNC, Type EPC-40-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. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 4. Damp or Wet Locations: GRC.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- D. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

- C. Keep raceways at least **6 inches (150 mm)** away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- D. Complete raceway installation before starting conductor installation.
- E. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- F. Support conduit within **12 inches (300 mm)** of enclosures to which attached.
- G. 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.
- H. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- I. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- J. 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.
- K. Cut conduit perpendicular to the length. For conduits **2-inch (53-mm)** trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- L. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than **200-lb (90-kg)** tensile strength. Leave at least **12 inches (300 mm)** of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- M. 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.
- N. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- O. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed **30 deg F (17 deg C)** and that has straight-run length that exceeds **25 feet (7.6 m)**. Install in each run of aboveground RMC[and EMT] conduit that is located where environmental temperature change may exceed **100 deg F (55 deg C)** and that has straight-run length that exceeds **100 feet (30 m)**.
- P. Locate boxes so that cover or plate will not span different building finishes.
- Q. 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.
- R. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

- S. Set metal floor boxes level and flush with finished floor surface.

3.3 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 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 26 05 33

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 raceways, conductors, and warning labels and signs.
 - 2. Labels.

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.
- C. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 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. 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."
- C. Equipment Identification Labels:
 - 1. Black letters on a white field.

2.2 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. 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 electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

- K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "POWER."
 - 3. "EMERGENCY BATTERY INVERTER."
- L. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- M. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- N. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- O. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- P. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
 - 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of **6 inches (150 mm)** where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- Q. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- R. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- S. Underground Line Warning Tape:
 - 1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at **6 to 8 inches (150 to 200 mm)** below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [or concrete envelope] exceeds **16 inches (400 mm)** overall.
 - 2. Limit use of underground-line warning tape to direct-buried cables.
 - 3. Install underground-line warning tape for direct-buried cables and cables in raceways.
- T. Metal Tags:
 - 1. Place in a location with high visibility and accessibility.
 - 2. Secure using general-purpose cable ties.
- U. Baked-Enamel Signs:
 - 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 - 2. Unless otherwise indicated, provide a single line of text with **1/2-inch- (13-mm-)** high letters on minimum **1-1/2-inch- (38-mm-)** high sign; where two lines of text are required, use signs minimum **2 inches (50 mm)** high.
- V. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

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 of high visibility. Identify by system and circuit designation.
- C. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- D. Arc Flash Warning Labeling: Self-adhesive labels.
- E. Equipment Identification Labels:
 1. Indoor Equipment: Baked-enamel signs.
 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 label.
 - b. Enclosures and electrical cabinets.
 - c. Switchboards.
 - d. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - e. Enclosed switches.
 - f. Enclosed circuit breakers.
 - g. Enclosed controllers.
 - h. Variable-speed controllers.
 - i. Contactors.
 - j. Battery-inverter units.
 - k. Battery racks.
 - l. Power-generating units.

END OF SECTION 26 05 53

SECTION 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

A.Applicable requirements of Division 00 and Division 01 shall govern work in this section.

1.02 SCOPE

A.The electrical contractor shall retain the services of an independent third party firm to perform a short circuit/coordination study as described herein.

B.The studies shall be submitted to the Design Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval from the Engineer may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.

C. At a minimum the studies shall include all portions of the electrical distribution system added to the facilities existing system, down to and including the smallest adjustable trip circuit breaker in the distribution system. Normal system connections and those which result in maximum fault conditions shall be adequately covered in the study. The studies shall incorporate or be an extension of the facilities existing system studies, where available.

D. An Arc Flash Hazard Assessment shall be included as part of the study.

E.The firm should be currently involved in high- and low-voltage power system evaluation in the State of Illinois. Credentials of the individual(s) performing the study and background of the firm shall be submitted to the Engineer for approval prior to start of the work. A minimum of five (5) years experience in power system analysis is required for the individual in charge of the project.

F. The firm performing the study should demonstrate capability and experience to provide assistance during start up as required.

1.03 DATA COLLECTION FOR THE STUDY

A.The contractor shall provide the required data for preparation of the studies. The Engineer performing the system studies shall furnish the Contractor with a listing of the required data immediately after award of the contract.

- B. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.

1.04 RELATED WORK

- A. Section 262816 – Enclosed Switches and Circuit Breakers

1.05 SUBMITTALS

- A. Third party qualifications. Submit qualifications of individual(s) who will perform the work for approval prior to commencement of the studies.

- B. Draft report. Submit a draft of the study to Engineer for review prior to delivery of the study to the Owner. Make all additions or changes as required by the reviewer.

- C. Final study report.

1. Provide studies in conjunction with equipment submittals to verify equipment ratings required.
2. The results of the power system study shall be summarized in a final report. Six (6) bound copies of the final report shall be submitted.
3. The report shall include the following sections:
 - a. Field study findings.
 - b. Descriptions, purpose, and scope of the study.
 - c. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
 - d. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
 - e. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

1.06 QUALITY ASSURANCE

- A. Reference standards listed in the IEEE "Buff Book", latest edition.

- B. The short circuit study shall be performed with the aid of a digital computer program and shall be in accordance with the latest applicable IEEE and ANSI standards.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 SHORT CIRCUIT AND PROTECTIVE DEVICE EVALUATION AND COORDINATION STUDY

- A. In the short circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, typical calculations, and recommendations. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, and other significant locations throughout the system. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance data. Include in tabulations fault impedance, X to R ratios, asymmetry factors, motor contribution, short circuit KVA, and symmetrical and asymmetrical fault currents.
- B. In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Include with each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered by that particular curve sheet. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.
- C. Include on the curve sheets power company relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent transformer characteristics, pertinent motor and generator characteristics, and characteristics of other system load protective devices. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panelboards.
- D. Include all adjustable settings for ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load and 150, 400, or 600 percent currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical and asymmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed.
- E. Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics, including a point equal to 58 percent of the ANSI withstand point to provide secondary line-to-ground fault protection. Where the primary device characteristic is not within the transformer characteristics, show a transformer damage curve. Separate transformer primary

protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults.

- F. Include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors, or generators as noted on drawings and one-lines.
- G. Utilize equipment load data for the study obtained by the Contractor from Contract Documents, including Contract Addendums issued prior to bid openings.
- H. Include fault contribution of all motors in the study. Notify the Engineer in writing of circuit protective devices not properly rated for fault conditions.
- I. Provide settings for the chiller motor starters or obtain from the mechanical contractor, include in the study package, and comment.
- J. For the emergency generators, include phase and ground coordination of the generator protective devices. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices. Obtain the information from the generator manufacturer and include the generator actual impedance value, time constants and current boost data in the study. Do not use typical values for the generator.
- K. Evaluate proper operation of the ground relays in 4-wire distributions with more than one main service circuit breaker, or when generators are provided, and discuss the neutral grounds and ground fault current flows during a neutral to ground fault.
- L. For motor control circuits, show the MCC full-load current plus symmetrical and asymmetrical of the largest motor starting current to ensure protective devices will not trip major or group operation.

3.02 FIELD SETTINGS

- A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study, protective device evaluation study, and protective device coordination study.
- B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the approved short circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the owner.

3.03 ARC FLASH HAZARD ASSESSMENT

- A. The Arc Flash Hazard portion of the study shall include the following as a minimum. Determine and document all possible utility and generator/emergency sources that are capable of being connected to each piece of electrical gear. Calculations shall be based on highest possible source connection.
- B. Calculations to conform to the latest edition of National Fire Protection Association (NFPA) 70E calculation standards. All incident energy units shall be calculated in calories per square centimeter.
- C. Provide recommended boundary zones and personal protective equipment (PPE) based on the calculated incident energy and the requirements of the NFPA 70E for each piece of electrical gear.
- D. Arc flash hazard study shall be performed by an engineer with professional registration and who has prepared a minimum of five arc flash hazard assessment studies.

END OF SECTION 26 05 73

SECTION 26 09 23 - 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. Indoor occupancy and vacancy sensors.
 - 2. Indoor and indoor daylight sensors.
 - 3. Outdoor daylight sensors.
- 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.
 - c. Daylight 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.

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 devices.
 - 2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY AND VACANCY SENSORS

- A. General Requirements for Sensors:
 - 1. Manufacturers: Acuity (nLight) or approved equivalent.
 - 2. Wall-mounted, solid-state indoor occupancy and vacancy sensors.
 - 3. Field selectable programming (for occupancy or vacancy based functions)
 - 4. Passive Infrared Technology or Dual Technology (PIR and Ultrasonic/Microphonic), type as scheduled.
 - 5. Operation:
 - a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - b. 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.
 - 6. Power Pack: Dry contacts rated for 20-A ballast or 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.
 - 7. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - 8. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 - 9. Bypass Switch: Override the "on" function in case of sensor failure.
 - 10. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

11. Auxiliary Contacts: Provide auxiliary contacts for interface with mechanical systems for occupancy based VAV box control where indicated on drawings/schedules. State of lighting system (on, off, etc) shall be separate from the programming state of VAV box. Only occupancy status off room or area shall be provided to mechanical system via auxiliary contacts.

2.2 INDOOR DAYLIGHT SENSORS

A. General Requirements for Sensors:

1. Manufacturers: Acuity (nLight) or approved equivalent.
2. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
 - a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 - b. Relay unit in subparagraph below is suitable for controlling a single lighting circuit, provided the circuit load does not exceed the listed aggregate load.
 - c. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 - d. Retain second option in first subparagraph below for lighting control of interior spaces with large window areas, including atriums and corridors; otherwise, retain first option.
 - e. Light-Level Monitoring Range: 100 to 1000 fc (1080 to 10 800 lx)], with an adjustment for turn-on and turn-off levels within that range.
 - f. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 - a. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.3 OUTDOOR DAYLIGHT SENSORS

A. General Requirements for Sensors:

1. Manufacturers: Acuity (nLight) or approved equivalent.
2. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
 - a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
 - b. Time Delay: 15-second minimum, to prevent false operation.
 - c. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
 - d. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

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 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 1/2 inch (13 mm).
- 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.

3.4 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.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and 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:
 - 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.
- D. Lighting control devices will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 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.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 26 09 23

SECTION 26 09 43 - RELAY-BASED 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: Networked lighting control power pack(s) using control-voltage relays for switching.

1.3 DEFINITIONS

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.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field quality-control reports.
- C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- D. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls 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. Lighting Control Relays: Equal to 10 percent of amount installed for each size indicated, but no fewer than 2.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panels for installation according to NECA 407.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multipreset modular dimming controls that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Damage from transient voltage surges.
 - 2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, shall open or close one or more lighting control relays in the lighting control power pack. Any combination of inputs shall be programmable to any number of control relays.
- B. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.
- 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 47 CFR 15, Subparts A and B, for Class A digital devices.
- E. Comply with UL 916.

2.2 LIGHTING CONTROL PANELS

- A. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.
 - 1. Timing Unit:
 - a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
 - b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
 - c. Schedule periods settable to the minute.
 - d. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
 - 2. Sequencing Control with Override:
 - a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
 - b. Sequencing control shall operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
 - c. Override control shall allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
 - d. Override control "blink warning" shall warn occupants approximately five minutes before actuating the off sequence.
 - 3. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation, including accurate time of day and date.
 - 4. Ethernet Communications: Comply with TCP/IP protocol. The main control unit shall provide for programming of all control functions of the main and all networked slave lighting control panels including timing, sequencing, and overriding.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panels according to NECA 407.

3.2 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
 - 1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Comply with NECA 1.

- D. Install panels and accessories according to NECA 407.

3.3 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.
 - 1. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Lighting control panel will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.4 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.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 26 09 43

SECTION 26 24 16 - 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. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Include evidence of NRTL listing for series rating of installed 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.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Panelboard Schedules: For installation in panelboards. 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 Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
 - 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. 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.

- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

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 NECA 407 and NEMA PB 1.

1.10 PROJECT 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.
- 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 two 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 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: Flush- and surface-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 3. 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.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 - 4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- B. Incoming Mains Location: Top and bottom.
- C. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
- D. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Main and Neutral Lugs: Mechanical.
 - 2. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 - 3. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 4. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. [Eaton Electrical Inc.](#)

2. [Siemens Energy & Automation, Inc.](#)
3. Square D, Inc
4. Or approved equal.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than **36 inches (914 mm)** high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in or 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 Inc.](#)
2. [Siemens Energy & Automation, Inc.](#)
3. Square D, Inc
4. Or approved equal.

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: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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

1. [Eaton Electrical Inc.](#)
2. [Siemens Energy & Automation, Inc.](#)
3. Square D, Inc
4. Or approved equal.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
3. Ground-Fault Equipment Protection (GFE) Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260914 "Electrical Power Monitoring and Control"
 - d. Shunt Trip: 120 or 24-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NECA 407 or NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NECA 407 or NEMA PB 1.1.
- B. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to panelboards.
 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

- D. Mount top of trim [90 inches (2286 mm)] above finished floor unless otherwise indicated.
- E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- F. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- G. Install filler plates in unused spaces.
- H. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- I. Comply with NECA 1.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

E. 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 panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. 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.

- F. Panelboards will be considered defective if they do not pass tests and inspections.

- G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

SECTION 26 27 02 - EQUIPMENT CONNECTIONS

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

- A. Applicable requirements of Division 0 and Division 1 shall govern work in this section.

1.2 DESCRIPTION

- A. Provide power and selected control wiring for all equipment including (but not limited to):
 - 1. HVAC motors and panels.
- B. Coordinate all equipment requirements with the various Contractors and Owner. Review the complete set of drawings and specifications to determine extent of wiring, starters, devices, etc. required.

1.3 RELATED WORK AND REQUIREMENTS

- A. Section 26 05 19 – Low Voltage Electrical Power Conductors and Cables
- B. Section 26 05 33 – Raceway and Boxes for Electrical Systems

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 HVAC AND PLUMBING CONNECTIONS

- A. Provide all power wiring including all circuitry carrying electrical energy from panelboard or other source through starters and disconnects to motors or to packaged control panels. Packaged control panels may include disconnects and starters and overcurrent protection. Provide all wiring between packaged control panels and motors. Include starters disconnects and overload protection if not included in packaged control panels.
- B. Provide connection to variable frequency drives (VFD) (furnished by others) to include wiring from the drive to the motors and interconnecting of included isolation transformers. VFD and transformer setting by Division 23.
- C. Provide 120 volts to each temperature control panel.
- D. Unless otherwise specified, all electrical motors and control devices such as aquastats, float and pressure fan powered VAV boxes, switches, electropneumatic switches, solenoid valves and damper motors requiring mechanical connections shall be furnished, installed and wired by Contractor supplying the devices.
- E. Each motor terminal box shall be connected with a maximum 18" piece of flexible conduit to a fixed junction box. A green wire run through the flexible conduit shall interconnect the motor frame and the rigid conduit system. Use Liquidtight flexible non-metal conduit for connections.
- F. Check for proper rotation of each motor.

END OF SECTION 26 27 02

SECTION 26 27 13 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes equipment for utility company's electricity metering.

1.2 SUBMITTALS

- A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS

- A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual.
- B. Shop Drawings:
 - 1. Layout Drawings: Dimensioned plans and sections or elevation layouts.
 - 2. Wiring Diagrams: Power, signal, and control wiring specific to this Project. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
 - 1. Electrical Acceptance Testing Responsibilities.
 - 2. General Electrical Field Quality Control.
 - 3. Testing Agency Qualifications.
- B. Comply with ANSI/NETA ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems for field testing.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, store, and handle modular meter center as specified in NECA 400.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's or Owner's written permission.

1.9 COORDINATION

- A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
 1. Comply with requirements of utilities providing electrical power and communication services.
 2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 REGULATORY REQUIREMENTS

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

2.3 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

- A. Current-Transformer Cabinets: Comply with requirements of electrical power utility company.
- B. Meter Sockets: Comply with requirements of electrical power utility company.
- C. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with lugs only or disconnect device as indicated, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.
 1. Manufacturers:
 - a. Basis of Design: Square D; Schneider Electric
 - b. Eaton
 - c. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.
 2. Housing: NEMA 250, Type 1 (Indoor) or Type 3R enclosure (Exterior).
 3. Voltage: As indicated on drawings.
 4. Minimum Short-Circuit Rating: As indicated on drawings but not less than 10,000 amperes symmetrical at rated voltage.
 5. Main Disconnect Device: Circuit breaker or fusible switch, as indicated.
 6. Meter Socket: Type as approved by utility company, with rating coordinated with indicated tenant feeder circuit rating.

2.4 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

- A. Manufacturers:
 - 1. Basis of Design: Square D; Schneider Electric
 - 2. Eaton
 - 3. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.
- B. Electronic Meter: Electronic meters, measuring electricity use.
 - 1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 - 2. Display: Digital liquid crystal, indicating voltage per phase, current per phase, power per phase (kW and kVA), current time and date, historical data.
 - 3. Enclosure: NEMA 250, Type 1 or 3R as indicated, with hasp for padlocking or sealing.
 - 4. Identification: Comply with Division 26 Section "Identification for Electrical Systems."
 - 5. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
 - 6. Sensors: Current-sensing type, with current and voltage output, selected for optimum range and accuracy for ratings of circuits indicated for this application.
 - 7. Meter Accuracy: Nationally recognized testing laboratory certified to comply with ANSI standards.
 - 8. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
 - 9. Potential-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
 - 10. Auxiliary Output: For integration with Building Automation System (BAS) BAC-Net protocol.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 FIELD QUALITY CONTROL

- A. Inspection and Tests:
 - 1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Instrument Transformers", "Metering Devices", "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
 - a. Follow-up thermographic survey shall not be required.
 - b. Prepare test and inspection reports.

END OF SECTION 26 27 13

SECTION 26 27 26 - 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. Standard-grade receptacles, 125 V, 20 A.
 - 2. USB receptacles.
 - 3. GFCI receptacles, 125 V, 20 A.
 - 4. Toggle switches, 120/277 V, 20 A.
 - 5. Wall plates.

1.3 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.

1.4 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.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 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 use.
- B. Comply with NFPA 70.
- C. Comply with NEMA WD 1.
- D. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
- E. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- F. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: White or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Essential Electrical System: Red.
- G. Wall Plate Color: For plastic covers, match device color.
- H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

- A. Duplex Receptacles, 125 V, 20 A
 - 1. Description: Two pole, three wire, and self-grounding.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Standards: Comply with UL 498 and FS W-C-596.

- B. Tamper-Resistant Duplex Receptacles, 125 V, 20 A <TR>
 - 1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Standards: Comply with UL 498 and FS W-C-596.
 - 4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.
- C. Weather-Resistant Duplex Receptacle, 125 V, 20 A <WP>:
 - 1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Standards: Comply with UL 498.
 - 4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.
- D. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 20 A <TR WP>:
 - 1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Standards: Comply with UL 498.
 - 4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.3 USB RECEPTACLES

- A. USB Charging Receptacles <USB>:
 - 1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
 - 2. USB Receptacles: Dual, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
 - 3. Standards: Comply with UL 1310 and USB 3.0 devices.
- B. Tamper-Resistant Duplex and USB Charging Receptacles <TR USB>:
 - 1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.
 - 2. Line Voltage Receptacles: Two pole, three wire, and self-grounding; NEMA WD 6, Configuration 5-20R.
 - 3. USB Receptacles: Dual USB Type A & C, 5 V dc, and 2.1 A per receptacle (minimum).
 - 4. Standards: Comply with UL 498, UL 1310, USB 3.0 devices, and FS W-C-596.
 - 5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.4 GFCI RECEPTACLES, 125 V, 20 A

- A. Duplex GFCI Receptacles, 125 V, 20 A <GFI>:
 - 1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Type: Non-feed through.
 - 4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

- B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A <GFI>:
 - 1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Type: Non-feed through.
 - 4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
 - 5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.5 TOGGLE SWITCHES, 120/277 V, 20 A

- A. Single-Pole Switches, 120/277 V, 20 A:
 - 1. Standards: Comply with UL 20 and FS W-S-896.
- B. Two-Pole Switches, 120/277 V, 20 A :
 - 1. Comply with UL 20 and FS W-S-896.
- C. Three-Way Switches, 120/277 V, 20 A:
 - 1. Comply with UL 20 and FS W-S-896.
- D. Four-Way Switches, 120/277 V, 20 A:
 - 1. Standards: Comply with UL 20 and FS W-S-896.
- E. Pilot-Light, Single-Pole Switches: 120/277 V, 20 A <L>:
 - 1. Description: Illuminated when switch is [on] [off].
 - 2. Standards: Comply with UL 20 and FS W-S-896.

2.6 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. 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: Smooth, high-impact thermoplastic 0.035-inch- (1-mm-) thick, satin-finished,.
 - 3. Material for Unfinished Spaces: Galvanized steel
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant[, die-cast aluminum] [thermoplastic] with lockable cover.

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 comply with 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. Pigtail 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 (152 mm) 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.

3.2 IDENTIFICATION

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

- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
- C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.3 FIELD QUALITY CONTROL

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Tests for 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.
- D. Wiring device will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 26 27 26

SECTION 26 28 13 - 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. Enclosed controllers.
 - b. Enclosed switches.
 - 2. Spare-fuse cabinets.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. 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-5: 600-V, zero- to 600-A rating, 200 kAIC.
 - 2. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
- 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.

2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
 - 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

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 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 26 28 13

SECTION 26 28 16 - 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 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

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 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than **minus 22 deg F (minus 30 deg C)** and not exceeding **104 deg F (40 deg C)**.
 2. Altitude: Not exceeding **6600 feet (2010 m)**.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, 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 an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty:
 1. Single throw.
 2. Three pole.
 3. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- B. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Three Pole, 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.

2.4 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

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.
 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

- A. 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 Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
 2. Indicate method of providing temporary electric service.

3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

3.4 ADJUSTING

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

END OF SECTION 26 28 16

SECTION 26 51 19 - 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. 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.
- B. Shop Drawings: For nonstandard or custom luminaires.
 - 1. Include plans, elevations, sections, and mounting and attachment details.

2. Include details of luminaire 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) 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. Luminaires.
 2. Suspended ceiling components.
 3. Partitions and millwork that penetrate the ceiling or extend to within **12 inches (300 mm)** of the plane of the luminaires.
 4. Structural members to which [equipment] [and] [or] luminaires will be attached.
 5. Initial access modules for acoustical tile, including size and locations.
- B. Qualification Data: For testing laboratory providing photometric data for luminaires.
- C. Product Certificates: For each type of luminaire.
- D. Product Test Reports: For each type of luminaire, for tests performed by [manufacturer and witnessed by a qualified testing agency] [a qualified testing agency].
- E. 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 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 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. 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.

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 luminaire installation.
- C. 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 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 a vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaires:
 - 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 Luminaires:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:
 - a. Two ~~5/32-inch-~~ (4-mm-) air aircraft cable supports adjustable to 10 feet (3 m) in length.
2. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
3. 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.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. 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.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

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. 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.

3.5 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] <Insert number> 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 26 51 19

SECTION 26 56 00 – EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section provides specifications and design criteria for the following:

1. Exterior luminaires and their associated lamps, ballasts and accessories.
2. Photoelectric controls integral to luminaires.
3. Poles, luminaire support structures and their associated accessories.

1.02 DEFINITIONS

- A. CRI: Color-rendering index.
- B. HID: High-intensity discharge.
- C. Luminaire: A complete lighting assembly or product consisting of not less than a light source(s) and related devices to position the light source(s), housing or enclosure, light source control and optics and light source power supply control device(s).
- D. NRTL: Nationally recognized testing laboratory.
- E. Pole: Luminaire support structure, including tower for large area illumination.
- F. Solid State Lighting/Luminaires: Light sources and their associated luminaires that produce light (radiant energy) without the use of electrical filaments, excited gas or plasma, such as LED, OLED, or PLED.
- G. Standard: Same definition as "Pole" above.
- H. TGIC – Triglycidyl Isocyanurate polyester powder type paint finish.

1.03 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.
- B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4.
- C. Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4.
- D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

1. Wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 110 mph (177 km/h)

1.04 SUBMITTALS

- A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.05 ACTION SUBMITTALS

- A. Product Data: Provide for each luminaire, pole, and support component, arranged in order of Luminaire Schedule designation. Include data relating to features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire finish and color information.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

- a. Photometric data shall be certified by a qualified independent testing agency.

6. Photoelectric control relays.
7. Ballasts, Power Supplies and Drivers: Provide separate data sheet, per luminaire tag, proving specification and design criteria written herein.
8. Lamps: Provide separate data sheet, per luminaire tag, providing specification and design criteria written herein.
9. Pole and/or support structure data: Provide separate data sheet, per luminaire tag, indicating material(s), dimensions, finishes, accessories, etc. proving specification and design criteria written herein.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Pole and support structure anchor bolt information.
12. Pre-manufactured pole foundation information.

- B. Shop Drawings:

1. Anchor bolt templates keyed to specific poles and certified by manufacturer.
2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
3. Wiring Diagrams: Power and control wiring.

- C. Luminaire Samples for Verification: For specific products designated for sample submission in Luminaire Schedule, or herein, provide a fully functional, operating sample with not less than the following:

1. Lamp(s): As specified, install in sample luminaire.
 2. Cord and Plug: Wired to luminaire junction box or ballast.
 3. 120 VAC ballast (for ballasted luminaires).
 4. Delivered with the specified finish/color applied, or submitted with a finish and color sample for evaluation.
- D. Finish and Color Samples for Verification: Where designated in the Luminaire Schedule, or herein, provided the following:
1. A factory supplied 3" x 5" sample of the specified finish and color, applied on the specified material.
- E. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire has been included in design.

1.06 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For agencies providing photometric data for luminaires.
- B. Field quality control test reports.

1.07 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires poles luminaire lowering devices to include in emergency, operation, and maintenance manuals.
- B. Warranty: Special warranty specified in this Section.

1.08 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Solid State Lighting/Luminaires:
 1. Luminous flux, luminaire efficiency and chromaticity shall be tested, measured and reported in accordance with the most current versions of IES documents LM-79 and LM-80.
 2. Chromaticity ranges for "white light" products, with various correlated color temperatures, shall be provided in accordance with ANSI/NEMA-C78.377.
 3. Drivers and power supplies shall be provided in accordance with the requirements of ANSI/NEMA-C82.SSL1 and their maximum allowable harmonic emission limits shall be in accordance with ANSI/NEMA-C82.77.
 4. Shall be provided with a U.S. Department of Energy (DOE) "Lighting Facts" label indicating their specific performance characteristics, tested and reported in accordance with the requirements of the most current version of IES LM-79.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C2, "National Electrical Safety Code."
- E. Comply with NFPA 70.
- F. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
 - 1. Electrical Acceptance Testing Responsibilities
 - 2. General Electrical Field Quality Control
 - 3. Testing Agency Qualifications

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Handle poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.
- D. Retain factory applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- E. Retain factory applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five (5) years from date of Substantial Completion.
 - 2. Warranty Period for Luminaire Metal Corrosion: Five (5) years from date of Substantial Completion.
 - 3. Warranty Period for Luminaire Color Retention: Five (5) years from date of Substantial Completion.
 - 4. Warranty Period for fluorescent Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.

5. Warranty Period for Poles and Support Structures: Repair or replace poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three (3) years from date of Substantial Completion.
6. Warranties for LED Luminaire: Written warranty, executed by manufacturer agreeing to replace luminaires, including labor, exhibiting a failure of LED modules for LED drivers within five (5) years.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with the requirements of this section and the design criteria specified in the Luminaire Schedule, provide products by the manufacturers listed in the Luminaire Schedule.
- B. Reference to specific manufacturers and their respective model or series numbers, are included in the Luminaire Schedule to provide a guide as to the level of quality, performance, and overall physical appearance of the specified product, which shall be met, in accordance with the Luminaire Schedule's design criteria, and as written herein.
- C. Listed manufacturers and their series or model numbers shall not imply unconditional specification approval. The listed manufacturers and their respective products have been included as acceptable manufacturers of products which shall comply with the Luminaire Schedule design criteria, luminaire, pole and accessory descriptions, and these specifications. Modification to a given manufacturer's standard product may be required to make the model or series numbers listed comply with the Luminaire Schedule design criteria, and these specifications.
 1. The preceding paragraph shall in no way suggest or indicate that a manufacturer's UL listing be voided or otherwise compromised, in order to comply with the specified luminaire design criteria, descriptions or these specifications.
- D. Products and Accessory Manufacturers: Subject to compliance with the requirements of this section, provide products from the manufacturers included herein.
- E. Manufacturers of products not specifically listed in the Luminaire Schedule, or submitting on the basis of "or equivalent", or "as approved", shall provide the following for review prior to, or along with product submission.
 1. Documentation showing a minimum of three years experience in the business of the design and manufacture of lighting equipment similar to the type and quality of products specified.
 2. Product data and photometry demonstrating conformance with these specifications and the specific data included in the Luminaire Schedule.
 3. Prototype and/or operating sample of the product for evaluation by the Architect/Engineer. Prototype and/or sample shall be sufficiently detailed and operational to allow for fair evaluation and to demonstrate compliance with the salient features specified. Product data and shop fabrication drawings are not acceptable means of providing prototype/sample requirement.

4. Architect/Engineer shall be the sole judge of compliance and reserves the right to disapprove manufacturer's products other than what has been previously specified.

2.02 LUMINAIRES, GENERAL REQUIREMENTS

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- G. Exposed Hardware Material: Stainless steel.
- H. Non Metallic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- J. 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.
- K. Lenses and Refractors Gaskets: Use heat and aging resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- L. Luminaire Finish: Except as otherwise noted or specified, manufacturer's standard paint finish applied to factory assembled and tested luminaire before shipping. Where indicated, provide finish process and color specified.
- M. 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.

2.03 PHOTOELECTRONIC CONTROLS INTEGRAL TO LUMINAIRE

A. Integral, Luminaire Installed, Photocell:

1. Where specified, scheduled and or otherwise indicated, provide a photo-electronic device designed, built, and tested to provide automatic, ON/OFF, dusk to dawn control of an individual luminaire, based on ambient daylight level.
2. Shall be UL 773A listed and fabricated to meet or exceed the requirements of ANSI C136.10, with integral relay contacts rated not less than 1000 VA to a ballasted load at not less than 300VAC.
3. Provided with integral time delay feature to prevent false operation after momentary light flashes or light blockages.
4. Reference Product: By luminaire manufacturer

2.04 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.

1. Wind Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless steel items are indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: May be cast in place or factory precast.

1. Refer to drawing details for cast in place foundation dimensional and construction requirements.
 - a. Anchor bolts specific to the design of the exterior lighting poles shall be furnished to the contractor for installation and embedment within the pole foundations.
 - b. Contractor shall provide raceways, grounding electrodes, and other electric work relating to the pole foundations.
2. Refer to Division 03 Section "Cast-in-Place Concrete" for earthwork, concrete, reinforcement, formwork, and erection specifications.

3. Factory precast foundations shall be fabricated to the dimensional and construction requirements indicated on the drawing details.
 - a. Anchor bolt specifications, specific to the design of the exterior lighting poles, shall be provided to the precast fabricator for their installation and embedment within the precast pole foundations.
 - b. Raceway requirements (size, quantity, and locations) shall be provided by the contractor, to the precast fabricator, for installation and embedment with the precast pole foundations.
 - c. Precast concrete foundation designs shall be engineered by a professional structural engineer, licensed in the locale, and shall be so identified."
- E. Power Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- F. Breakaway Supports: Where indicated on the drawings, provide frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.05 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
 1. Shape: Square straight unless specified otherwise in Luminaire Schedule.
 2. Erection Provisions: Butt flange for bolted installation on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Handhole: Provide handhole opening, nominal 3" x 5", at approximately 18" above pole base, complete with weathertight cover and securing fastener.
- E. Grounding and Bonding Lugs: Welded ½ inch (13 mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding " listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- F. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, and then bolted together with stainless steel bolts.
 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 2. Finish: Same as luminaire.
- G. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

- H. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.06 IN-LINE FUSING

- A. Shall be UL listed and labeled, single pole, 600VAC, breakaway style, in-line fuse holders, designed for field installation onto pole supported luminaires.
- B. Shall be two part device, consisting of water resistant type lineside and loadside mechanical crimp connector terminals to accept stranded or solid conductors, with insulating boots, designed to accept midget size fuses up to 30A.
- C. Provide complete with fuses, sized to the specific load.
- D. Referenced Product:
 - 1. Cooper/Bussmann – "TRON" HEB series.

PART 3 - EXECUTION

3.01 LUMINAIRE INSTALLATION

- A. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- B. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.
- C. Provide box wiring identification per Division 26 Section "Electrical Identification."

3.02 POLE INSTALLATION

- A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
 - 3. Trees: 15 feet (5 m).
- C. Refer to drawing details for additional information regarding foundation dimensions, projections above grade, and other site-specific criteria.

- D. Site Fabricated, Cast in Place, Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Precast Concrete Pole Foundations:
 - 1. Follow the precast concrete foundation fabricator's handling and erection directions for installation.
- F. Foundation Erected Poles: Install pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Erect and secure poles to foundations, plumb and level.
 - 3. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 4. Install base covers, unless otherwise indicated.
 - 5. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- G. Poles and Pole Foundations Set in Concrete Paved Areas: Except as otherwise noted, install poles with minimum of 6-inch- (150 mm) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
- H. Raise and set poles using web fabric slings (not chain or cable).

3.03 BOLLARD LUMINAIRE INSTALLATION

- A. Refer to drawing details for additional installation requirements.
- B. Align units for optimum directional alignment of light distribution.
- C. Except as otherwise noted, install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard 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 Division 03 Section "Cast-in-Place Concrete."

3.04 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Refer to drawing details for additional installation requirements.
- B. Except as otherwise noted, install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.05 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 Division 26 Section "Raceway." In concrete foundations, conduits shall be coated with an approved asphaltic paint, plastic coating or shall be wrapped with a single layer of a pressure-sensitive plastic tape, half lapped.

3.06 GROUNDING AND BONDING

- A. Bond metal poles and support structures according to Division 26 Section "Grounding and Bonding."
 - 1. Install a grounding electrode at each pole, unless otherwise indicated.
 - 2. Install a grounding electrode conductor at the base of each pole, bonded to the branch circuit equipment ground conductor.
- B. Bond nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding."
 - 1. Install a grounding electrode for each pole.
 - 2. Install a grounding electrode conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.07 FIELD QUALITY CONTROL

- A. Inspections and Tests:
 - 1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "System Functional Tests" and "Thermographic Survey" requirements, and the following additional requirements:
 - a. Follow-up thermographic survey shall not be required.
 - b. Prepare test and inspection reports.
 - c. Inspect each installed fixture for damage. Replace damaged fixtures and components.
 - d. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 1) Verify operation of photoelectric controls.
 - e. Illumination Tests:
 - 1) Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

- a) IESNA LM-5, "Photometric Measurements of Area and Sports Lighting."
- b) IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
- c) IESNA LM-64, "Photometric Measurements of Parking Areas."
- d) IESNA LM-72, "Directional Positioning of Photometric Data."

END OF SECTION 26 56 00

SECTION 27 05 26 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding labeling.

1.2 DEFINITIONS

- A. TBC: Bonding conductor for telecommunications.
- B. EMT: Electrical metallic tubing.
- C. SBB: Telecommunications grounding busbar.
- D. PBB: Telecommunications main grounding busbar.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 1. TBC, PBB, TGBs, and routing of their bonding conductors.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding 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. Result of the ground-resistance test, measured at the point of TBC connection.
 - b. Result of the bonding-resistance test at each SBB and its nearest grounding electrode.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician, who shall be present at all times when Work of this Section is performed at Project site.
 2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

- A. Comply with J-STD-607-A.

2.2 CONDUCTORS

- A. Comply with UL 486A-486B.
- B. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 2. Cable Tray Equipment Grounding Wire: No. 8 AWG.
- C. Cable Tray Grounding Jumper:
 1. Not smaller than No. 10 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
- D. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

2.3 CONNECTORS

- 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. Chatsworth Products, Inc.
 - 3. Panduit Corp.
 - 4. TE Connectivity Ltd.
- B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
 - 1. Electroplated tinned copper, C and H shaped.
- D. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.
- E. Busbar Connectors: Cast silicon bronze, solderless compression or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.
- F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Chatsworth Products, Inc.
 - 2. Panduit Corp.
- B. PBB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as PBB and shall comply with J-STD-607-A.
 - 1. Predrilling shall be with holes for use with lugs specified in this Section.
 - 2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 - 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. SBB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 or 4 inches in cross section, length and width as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.
1. Rack-Mounted Vertical Busbar: 72 inches long, with stainless-steel or copper-plated hardware for attachment to the rack.
 2. Provide one vertical busbar per rack.

2.5 LABELING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brother International Corporation.
 2. HellermannTyton.
 3. Panduit Corp.
- B. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of TBC connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the TBC only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with J-STD-607-A.

3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the PBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.
- D. Conductor Support:
 - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches.
- E. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Support at not more than 36-inch intervals.
 - 4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 260533 "Raceways & Boxes for Electrical Systems," and bond both ends of the conduit to a SBB.

3.4 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.
- B. 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.

3.5 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 - 1. Use crimping tool and the die specific to the connector.
 - 2. Pretwist the conductor.
 - 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the PBB with insulated bonding conductor.
- E. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install vertically mounted rack bonding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the SBB No. 2 AWG bonding conductors.
- F. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
- G. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each SBB to the ground bar of the panelboard.
- H. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
- I. Access Floors: Bond all metal parts of access floors to the SBB.
 - 1. Waveguides and Coaxial Cable:
 - a. Bond cable shields at the point of entry into the building to the SBB and to the cable entrance plate, using No. 2 AWG bonding conductors.
 - b. Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

3.6 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 - 1. Label PBB(s) with "fs-PBB," where "fs" is the telecommunications space identifier for the space containing the PBB.
 - 2. Label SBB(s) with "fs-SBB," where "fs" is the telecommunications space identifier for the space containing the SBB.
 - 3. Label the TBC and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a PBB and a SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 - 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- C. Excessive Ground Resistance: If resistance to ground at the TBC exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 27 05 26

SECTION 27 05 28 - PATHWAYS 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. Metal conduits and fittings.
 - 2. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.
- D. RTRC: Reinforced thermosetting resin conduit.

1.4 ACTION SUBMITTALS

- A. Product data for the following:
 - 1. Wireways and fittings.
 - 2. Boxes, enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets and custom underground handholes and boxes. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
 - 3. Underground ducts, piping, and structures in location of underground enclosures and handholes.

- B. Qualification Data: For professional engineer.
- C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
 - 2. Comply with TIA-569-D.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. EMT: Comply with ANSI C80.3 and UL 797.
- G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.
- H. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 HOOKS

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with TIA-569-D.
- D. Galvanized steel.
- E. J shape.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-D.
 - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 - 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 - 4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep)]Gangable boxes are allowed.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. 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.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Concealed in Ceilings and Interior Walls and Partitions: EMT.
- B. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.
- C. Pathway Fittings: Compatible with pathways 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.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- E. Install surface pathways only where indicated on Drawings.

3.2 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA/BICSI 568.
 - 3. TIA-569-D.
 - 4. NECA 101
 - 5. NECA 102.
 - 6. NECA 105.
 - 7. NECA 111.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- D. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- E. Complete pathway installation before starting conductor installation.
- F. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- G. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.
- H. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- I. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- J. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for pathways.
 - 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 pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- O. 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.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- R. Hooks:
 - 1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 - 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 - 3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 - 4. Space hooks no more than 5 feet (1.5 m) o.c.
 - 5. Provide a hook at each change in direction.
- S. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to [center] [top] [bottom] of box unless otherwise indicated.
- T. 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 surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- U. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- V. 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.
- W. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- X. Set metal floor boxes level and flush with finished floor surface.
- Y. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or 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 27 05 28

SECTION 27 60 00 - SYSTEM ROUGH-IN REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This section includes miscellaneous raceway system as shown or implied on the Contractor Documents for the following systems:
 - 1. Communication horizontal cabling.
- B. Related Sections include the following:
 - 1. Division 26 Section "Grounding and Bonding Electrical Systems"
 - 2. Division 26 Section "Raceway and Boxes for Electrical Systems"
 - 3. Division 26 Section "Identification for Electrical Systems"

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Raceway shall be EMT with compression fitting and conduit bushing at both ends. Rough-in box will be minimum 2-1/4" deep. Minimum size shall be as follows:
 - 1. Communication horizontal cabling: 3/4" conduit trade size or as noted otherwise on construction drawings.
- B. Rough-In Box:
 - 1. Communication horizontal cabling rough-ins shall be 4" X 4", deep rough-in box with single plaster ring.
- C. A/V Rough-In:
 - 1. As indicated on construction plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- 1. Raceways shall be installed from outlets to accessible area above ceiling as indicated by Contract Documents. Conduit shall terminate with bushing
- 2. Outlet mounting height shall be as follows unless indicated otherwise by Contract Documents:

Malcolm X College – West Side Learning Center
Addition and Renovations

- a. Communication horizontal cables: +18" above finished floor to center and 2" above back splash, wall mounted telephone at 48" AFF unless noted otherwise.
- 3. Provide nylon pullcord in raceway system.

END OF SECTION 27 60 00

28 31 00 - FIRE ALARM DETECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes a new intelligent addressable fire alarm and detection system with speaker/strobe notification and all required parts, cabling, and accessories. Provide new fire alarm system as outlined below and as shown on floor plans.
- B. Installation of new system shall be phased with demolition of existing system. New system shall be fully functional and tested prior to demolition of existing system.
- C. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials, and performing all operations in connection with the installation of the multiplexed intelligent Fire Alarm System as shown on the drawings, and as hereinafter specified.
- D. Related Sections include the following:
 - 1. Division 08 Section "Door Hardware" for door closers and holders with associated smoke detectors, electric door locks, and release devices that interface with the fire alarm system.
 - 2. Division 21 Section "Fire Protection" for waterflow and tamper switches, alarm check valves, and fire pump devices that interface with the fire alarm system.
 - 3. Division 26 Sections for components and methods of the fire alarm system installation.

1.2 DEFINITIONS

- A. ADS: Acoustically Distinguishable Spaces – a notification appliance(s) zone distinguishable from other spaces because of different acoustical, environmental, or use characteristics.
- B. BAS: Building Automation System.
- C. CIS: Common Intelligibility Scale.
- D. FACU: Fire Alarm Control Unit.
- E. FATC: Fire Alarm Terminal Cabinet.
- F. FPC: Fire Alarm Personal Computer.
- G. FPU: Field Processing Unit.
- H. LCD: Liquid Crystal Display.
- I. LED: Light-Emitting Diode.
- J. MNS: Mass Notification System.
- K. NAC: Notification Appliance Circuit.
- L. NICET: National Institute for Certification in Engineering Technologies.
- M. UPS: Uninterruptible Power Supply.

- N. Definitions in NFPA 72 apply to fire alarm terms used in this Section.

1.3 COORDINATION

- A. Recommend to owner and request approval of nameplate inscriptions, zone designations, and system designations on system annunciators and central control equipment prior to shop drawing submittals.
- B. Coordinate together with equipment suppliers and other Divisions, their equipment operational voltages and controls for proper system operation and interface requirements. Provide any necessary auxiliary equipment and software for system interfaces. The auxiliary equipment shall provide for, but not be limited to:
 - 1. Division 23 smoke control and fan shutdown interfaces.
 - 2. NAC extender panel(s) interfaces.
 - 3. Electro-magnetic door holder release interfaces.
 - 4. Security system door release interfaces.
 - 5. Rolling counter door power and interfaces.
 - 6. 120 volt power connections.
 - 7. Exact duct detector locations and quantities at air handling equipment and in HVAC ductwork.
 - 8. Exact waterflow and tamper switch locations and quantities in fire protection system.
 - 9. Non-system detectors and addressable relay interfaces.
 - 10. Wire guards per Section Division 26 Section "Wiring Devices."
 - 11. Telecommunications dedicated fiber optic backbone cabling interfaces for FCCC to FACU communications.
 - 12. Breaker handle clips and signage at panelboards servicing fire alarm devices.
- C. Nameplates shall be per Division 26 Section "Electrical Identification."
- D. All information for the system wiring shall be supplied by the manufacturer. The sizes of the different wires shall be those specified by the manufacturer. Building wire shall be in accordance with Division 26 Section "Low Voltage Electrical Power Conductors and Cables" and NEC articles 760, 775, and 800.
- E. Coordinate exact duct detector locations at air handling units and in return and exhaust HVAC ductwork.

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Division 26 Section "General Electrical Provisions".

1.5 ACTION SUBMITTALS

- A. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division 01 Section "Submittals," make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit

if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.

B. Equipment Shop Drawing Submittal:

1. Supplier qualifications.
2. Provide complete catalog cuts and specification sheets, itemized by contract drawing symbol, for all components to be installed as well as a general system operation description and control-by-event schedule. The submittal shall clearly depict UL listing and FM approval of system and components. The system operation description shall include the method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs. Description shall be applicable to this project. Manufacturer's standard descriptions for generic systems are not acceptable.
3. Provide itemized description/comparison of where and how equipment and operational items specified are accomplished if different than specified but meet the functional intent.
4. Provide scaled drawings for all terminal cabinets, panels and amplifiers. Submit complete coordination drawings depicting equipment and showing all major component sizes and locations at 1/4 inch scale minimum per Division 26 Section "General Electrical Provisions".
5. Provide spare parts listing.
6. Provide individual amplifier power supply, and FPU point size calculations indicating spare capacity.
7. Provide calculations for battery capacity for both alarm and supervisory modes.
8. Provide voltage drop calculations for typical Class A (and Class B) circuits and wire sizes identifying maximum length to limit voltage drop to 10 percent maximum.
9. Equipment quantities (for record only).
10. Original equipment manufacturer warranty statement.

C. Pre-Installation Shop Drawing Submittal:

1. Submit two full sets of shop drawings drawn specifically for the project, one set of associated reproducible shop drawings, five full sets of data sheets, and installation manuals instructions detailing the manufacturer's recommendations for all equipment installations.
2. A drawing symbol legend sheet (to match Contract Document legend wherever possible).
3. Floor plan drawings showing:
 - a. Locations of all fire detection, alarm, and notification system devices, equipment, risers and electrical power connections including unique addressing of each addressable device and circuit.
 - 1) Provide indicated and additional device location(s) based upon manufacturers recommendations if coverage or sensitivity is less than code required expectations based on Contract Drawings. Be responsible to verify with local authorities as appropriate. Supply such additional devices at no cost to Owner.

- b. Minimum expected notification appliance(s) dBA value for each room in the project scope when local appliance tap setting(s) are set at a lower (1/2 or 1 watt) of range; and expected average/maximum ambient dBA values for that room. This shall indicate audible level compliances.
 - c. Minimum expected notification appliance(s) CIS value for each room in the project scope when local application tap setting(s) are set at a lower (1/2 or 1 watt) of range; and expected average/maximum CIS values for that room. This shall indicate tone intelligibility level compliances and in conjunction with specific ADS zone requirements.
 - d. Routing, number, size and type of conductors; expected voltage drop, and conduit size and fill percentage.
 - e. Terminal-to-terminal wiring connections showing all individual circuits and circuit/conduit routing.
 - f. Conduit fill calculations indicating the cross section area percent fill for each type of wire/cable in each size of conduit used in the system.
 - g. Conduit routing and proposed height and method of coring.
 - h. System zoning including color coded floor plans showing both system input and output zones.
4. Detailed point to point wiring diagrams specific to the project for all alarm control panels, control panel modules, power supplies, electrical power connections, auxiliary function relays and remote annunciation equipment. Detail wiring diagrams shall show and identify all terminations, including terminal identifications, size and type of conductors.
- a. These diagrams shall depict and identify all circuit boards, modules, power supplies, dip switches, jumpers, leds, indicators, adjustable controls or components, ribbon connectors, wiring harnesses, terminal strips and connections thereto, including spare zones or circuits.
 - b. Diagrams required by this section shall depict the required information as to relative scale, actual size, or larger, showing proper spacial relationships between components.
5. A system riser diagram or diagrams showing:
- a. Number and size of riser conduits.
 - b. Number, size, type and function of conductors in each riser.
 - c. The number of each type of device on each floor and zone.
6. Each floor plan drawing, typical wiring diagram, detailed wiring diagram and system riser diagram shall be cross-referenced to all related drawings. It is intended that the complete submittal shall include all information necessary for system installation.
7. Device address list.
8. Each drawing will show the revision number and date in the title block.
9. Installer certifications and licensing.
10. Factory training information.

1.6 INFORMATIONAL SUBMITTALS

1. Field and quality control test reports.

1.7 AUTHORITY HAVING JURISDICTION FIRE ALARM PLAN APPROVAL

- A. Where fire protection system plan approval is required, the contractor shall prepare the submittal as required in this section in addition to distribution requirements for submittals specified in Division 1 Section "Submittals", make and identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.
- B. Any costs associated with this shall be included in the contractor's bid. Application for Approval. To be completed and submitted by the Contractor. Permit approval fees. Paid for by the contractor. Contractor shall note that fire alarm system shall be submitted and approved prior to the installation of the system.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Manual Submittal:
 1. Provide operation and maintenance data for inclusion in Operation and Maintenance Manual specified in Division 01 and in Section "General Electrical Provisions". Operation and maintenance data shall cover each type of product, including all features and operating sequences, both automatic and manual. Provide the name, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be furnished.
 2. Upon completion of the project, submit three copies of operation and maintenance manual, bound in a three-ring binder, containing:
 - a. A detailed narrative description of the system architecture, inputs, evacuation signaling, auxiliary functions, annunciation, intended sequence of operation, expansion capability, application considerations and limitations.
 - b. A detailed description of routine maintenance required or recommended, or as would be provided under a maintenance contract, including a maintenance schedule and detailed maintenance instructions for each type of device installed.
 - c. An equipment list/schedule detailing all equipment and quantities installed. The manufacturer's product model/identification number shall be shown next to each piece of equipment on the list.
 - d. Manufacturer's data sheets and installation manuals/instructions for all equipment installed.
 - e. A list of provided and recommended spare parts and accessories which the manufacturer recommends be stocked for maintenance of the system.
 - f. A detailed description of the operation of the systems, including operator responses. Copies of the approved sequence of operation shall be placed in, or adjacent to, the FACU and maintenance office as directed by Owner.

- g. Power supply and standby battery load calculations for each power supply in the system. Included with these calculations, a list shall be provided detailing the type, quantity and normal and alarm current for each type of device installed in the system.
 - h. Audio and visual load calculations for each notification application circuit, power supply and amplifier indicating spare capacity allowances in the system.
 - i. A complete riser diagram and 8-1/2 x 11-inch plasticized copies of all detailed wiring diagrams and control panel wiring diagrams, as approved for the contractor's record drawing submittal.
 - j. Complete software documentation and programming instructions.
 - k. Submit 6 extra sets of software user manuals.
 - l. Compact disk(s) of final approved shop drawings and operation and maintenance submittals.
 - m. Other requirements, defined by NFPA 72, Appendix A.
- B. Complete Buildings As-Built: Coordinate through the Construction Manager a complete set of as-built drawings for filing at the FACU for firefighter's use.
- C. Miscellaneous Submittals: Submittals for system certification, testing, and record drawings shall be per Division 01 and associated Part 3 article of Division 28 Section "Fire Alarm Systems."
- D. Documentation:
 - 1. Approval and Acceptance: Provide the "Record of Completion" form according to NFPA 72 to Owner, Engineer, and authorities having jurisdiction.
 - 2. Record of Completion Documents: Provide the "Permanent Records" according to NFPA 72 to Owner, Engineer, and authorities having jurisdiction. Format of the written sequence of operation shall be the optional input/output matrix.
 - a. Hard copies on paper to Owner (3), Engineer (1), and authorities having jurisdiction (1).
 - b. Provide hard copy at fire command center. Install in FATC cabinet used exclusively for these files.

1.9 SPARE PARTS

- A. General: Unless directed otherwise by owner, furnish spare part of matching products installed, as described below, and as recommended by the manufacturer, packaged with protective covering for storage, and identified with labels clearly describing contents.
 - 1. Two compact disk and hardcopy sets of all system software and graphics.
 - 2. Lamps for Remote Indicating Lamp Units: Furnish quantity equal to 5 percent of the number of units installed, but not less than six.
 - 3. Lamps for Strobe Units: Furnish quantity equal to 10 percent of the number of units installed.
 - 4. Manual Pull Stations, Control Modules, Monitor Modules, Isolator Modules, Smoke Detectors, Heat Detectors, Non-System Detectors: Furnish quantity equal to 5 percent of the number of units of each type installed.

5. Detector Bases: Furnish quantity equal to 2 percent of the number of units of each type installed.
 6. Notification Appliances: Furnish quantity equal to 10 percent of number of units of each type installed.
 7. Six spare fuses for each fused circuit in the system.
 8. Six sets of any special tools required.
 9. Twelve spare screws of each type installed.
 10. Six screwdrivers of each type needed for system repairs/maintenance.
 11. Keys and locks for all equipment shall be identified and identical where possible. Not less than 12 keys for each type required shall be provided. Key numbering chart shall be provided in each instruction manual furnished.
- B. Allowance: Furnish labor and material to install five smoke detectors and five notification devices to meet unknown final AHJ requirements. Include all raceway and cable for a fifty foot homerun from each device and all incidentals per the requirements of this Section, including circuit tie-ins and reprogramming.

1.10 MAINTENANCE SERVICES

- A. Maintenance Service Contract: Provide free maintenance of fire alarm systems and equipment for the duration of the original equipment manufacturers warranty period (minimum one year) commencing with Substantial Completion, using factory-authorized service representatives.
- B. Basic services: Systematic, routine maintenance visits on a monthly basis at times coordinated with the facility. In addition, respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies. Include option of automatic yearly or individual software enhancement prices.
- C. Additional Services: Perform services within the above warranty period not classified as routine maintenance or as warranty work as described in Division 01 Section "Warranties" when authorized in writing. Compensation for additional services must be agreed upon in writing prior to performing services.
- D. Renewal of Maintenance Service Contract: No later than 60 days prior to the expiration of the maintenance services contract, deliver to Owner a proposal to provide contract maintenance and repair services for an additional one-year term. Owner will be under no obligation to accept maintenance service contract renewal proposal.

1.11 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who is a factory-authorized service representative and licensed to perform the Work of this Section.
1. The equipment manufacturer shall have a local branch office with engineering and service departments staffed with trained, full time employees capable of testing, inspection, repair and maintenance services for the life of the fire alarm system.
 2. The equipment supplier shall make available to the Owner, the services of an authorized representative of the manufacturer to train facility maintenance personnel in the operation, programming and routine maintenance of the system.

3. The equipment supplier shall represent a major fire alarm equipment manufacturer and shall conform to and provide proof of the following:
 - a. Has represented the equipment manufacturer for a minimum of three years in the project area.
 - b. Has a local shop with all testing equipment and a complete local stock of replacement parts and materials for servicing the equipment supplied.
 - c. Has 24-hour emergency service for servicing equipment after normal working hours.
 - d. Has suitable finances to provide the work indicated, the guarantee required, and to provide future service on the equipment under contract or on-call basis.
 - e. Has trained, full time employees to provide necessary testing, inspection, repair and maintenance of the system. The service technicians must be certified by the project State's Department of Labor as Fire Alarm Journeymen Mechanics. National Institute for Certification in Engineering Technologies (NICET) level III certification shall be considered equal. A copy of NICET level III certification or state certification shall be submitted to the engineer with pre-installation shop drawing submittal.

1.12 COMPATIBILITY

- A. All new fire alarm systems and their associated components shall be of the same manufacturer's product line, except for special sub-systems or non-system detectors monitored by the main system.
- B. All key switches and lockable devices shall be keyed alike whenever possible.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. FACU and Equipment:
 - a. Johnson Controls / Simplex Tyco Grinnell
 - b. Siemens
 - c. Honeywell
 - d. EST
 2. Wire and Cable:
 - a. Belden
 - b. Comtran Corporation.
 - c. Helix/HiTemp Cables, Inc.; a Draka USA Company.
 - d. Rockbestos-Suprenant Cable Corporation; a Marmon Group Company.
 - e. West Penn Wire/CDT; a division of Cable Design Technologies.

f. Radix.

2.2 REGULATORY REQUIREMENTS

- A. Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations and the requirements of the authority having jurisdiction.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. ANSI Compliance: Provide a fire alarm and detection system conforming to ASME A17.1.
- D. NFPA Compliance: Provide a fire alarm and detection system conforming to the requirements of the following publications:
 - 1. NFPA 20 - Centrifugal Fire Pumps.
 - 2. NFPA 70 - "National Electrical Code."
 - a. NEC Article 725 - Class 1, 2 and 3 Signaling Circuits.
 - b. NEC Article 760 - Fire Protective Signaling Systems.
 - 3. NFPA 72 - National Fire Alarm Code.
 - 4. NFPA 90A - Air Conditioning Systems.
 - 5. NFPA 92A - Smoke Control Systems.
 - 6. NFPA 101 - Life Safety Code.
- E. Chicago Building Code Compliant: Provide a fire alarm and detection system conforming to the requirements of the Chicago Building Code and all referenced publications.
- F. The fire system installation company shall be licensed by the Project State to install fire alarm systems. A copy of the State fire alarm install license shall be submitted to the engineer with shop drawing submittal.
- G. UL Listing and Labeling: Provide system and components specified in this Section that are listed and labeled by UL and specific references as follows:
 - 1. UL 38 - Manually Actuated Signaling Boxes.
 - 2. UL 217 - Smoke Detectors, Single and Multiple Station.
 - 3. UL 228 - Door Closers-Holders for Fire Protective Signaling Systems.
 - 4. UL 268 - Smoke Detectors for Fire Protective Signaling Systems.
 - 5. UL 268A - Smoke Detectors for Duct Applications.
 - 6. UL 346 - Waterflow Indicators for Fire Protective Signaling Systems.
 - 7. UL 464 - Audible Signaling Appliances.
 - 8. UL 521 - Heat Detectors for Fire Protective Signaling Systems.
 - 9. UL 864 - Control Units for Fire Protective Signaling Systems.

10. UL 1480 - Speakers for Fire Protective Signaling Systems.
11. UL 1711 - Amplifiers for Fire Protective Signaling Systems.
12. UL 1481 Power Supplies for Fire Protective Signaling Systems.
13. UL 1638 - Visual Signaling Appliances.
14. The fire system shall comply with local building codes, and meet all requirements of the local authorities having jurisdiction. The complete fire alarm system installation shall be listed by Underwriters Laboratories, Inc. (U.L.) standard UUJS. All components of the fire system shall be U.L. listed.

- H. Factory Mutual (FM) Compliance: Provide fire alarm systems and components that are FM approved proprietary signaling systems.
- I. Single-Source Responsibility: Obtain fire alarm components from a single source who assumes responsibility for compatibility for system components furnished.
- J. Americans with Disabilities Act (ADA) - Latest Edition: Comply with all related fire alarm installation and operating requirements in the Federal ADA law and local accessibility codes.

2.3 SYSTEM DESCRIPTION

- A. Noncoded, addressable system; multiplexed signal transmission dedicated to fire alarm service only.
- B. Smoke/Fire Zones:
 1. Each floor shall be group zoned according to the smoke partition construction, with further breakdown as to the device type. Refer to Drawings for complete description of designated fire alarm zones. Additional zones shall be dedicated but not limited to:
 - a. Individual Air Handling Units.
 - b. Non-System Detectors
 - c. System detectors zoned per smoke compartment
 - d. Pre-Action Fire Suppression Systems.

2.4 PERFORMANCE REQUIREMENTS

- A. Comply with Chicago Fire Prevention Bureau requirements.
- B. Comply with NFPA 72 and local requirements.
- C. All fire alarm supervisory, and trouble system signals shall initiate the following actions:
 1. Identify signal condition type at the FACU, FPU's, and remote annunciator. Menuing shall allow further signal information such as location, type of device and device address.
 2. Record events in the system memory.
 3. Cause the device in alarm LED indicator to flash.
- D. Fire alarm signal initiation shall be by one or more of the following devices:

1. Manual stations.
 2. Heat detectors.
 3. Smoke detectors.
 4. Automatic sprinkler system water flow.
 5. Fire extinguishing system operation.
 6. Fire standpipe system.
 7. Duct Smoke detector (where permitted by the AHJ)
- E. Fire alarm signal shall initiate the following additional actions:
1. Alarm notification appliances shall operate continuously in synchronization.
 2. Transmit an alarm signal to the remote alarm receiving station.
 3. Unlock electric door locks in designated egress paths.
 4. Release fire and smoke doors held open by magnetic door holders.
 5. Stop supply and return fans per sequence of operation noted on the drawings.
 6. Signal the Division 23 base building BAS System of a system alarm such that the BAS intelligence can provide proper smoke and damper control. All associated signals and monitor point contacts shall be coordinated with the BAS subcontractor to provide BAS terminations. This Division 28 function is as follows:
 - a. Signal the Division 23 base building BAS System of an alarm in the building.
 - b. Signal the Division 23 base building BAS System of an RTU or AHU unit supply or return duct detector alarm such that the base building BAS intelligence can provide proper smoke control.
 - c. Shut down fans with controller fire alarm control modules (symbol FR) as shown on Drawings.
 7. Activation of local detectors associated with the following devices shall cause these devices to operate.
 - a. Rolling counter doors.
 - b. Electro-magnetic door hold release.
 - c. Power operated door release.
 8. Record events in the system memory.
- F. Supervisory signal initiation shall be by one or more of the following devices or actions:
1. Operation of a fire-protection system valve tamper switch.
 2. Low-air pressure switch operation on dry pipe or preaction sprinkler system.
 3. Non-system detector alarm contact signal.
- G. System trouble signal initiation shall be by one or more of the following devices or actions:

1. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
 2. Opening, tampering, or removal of central control equipment, alarm initiating, and supervisory signal initiating devices.
 3. Loss of primary power at the FACU.
 4. Ground or a single break in FACU internal circuits.
 5. Abnormal ac voltage at the FACU.
 6. A break in standby battery circuitry.
 7. Failure of battery charging.
 8. Abnormal position of any switch at the FACU or annunciator.
 9. Loss of connection to remote alarm receiving station.
- H. System Trouble and Supervisory Signal Actions: Ring trouble sounder and annunciate at the FACU, FPU's, and remote annunciators. Record the event on system printer.
- I. Bypass Control "Drill" Switches:
1. Activation of SEPARATE auxiliary bypass control switches shall override the automatic functions selectively within the system for:
 - a. Transmission of fire alarm condition signal to the remote alarm receiving station
 - b. Operation of audible alarms (but not affecting indicating alarms).
 - c. Operation of fire alarm visual alarms.
 - d. Operation of door release devices.
 - e. Automatic shutdown of HVAC equipment.
 - f. Automatic control of smoke dampers.
 2. Bypass control shall be overridden upon the activation of a subsequent alarm from another alarmed zone.

2.5 FACU

A. General Description:

1. Modular, power-limited design with electronic modules, UL 864 listed.
2. Addressable initiation devices that communicate device identity and status.
 - a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at the FACU.

- b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
 - 3. Addressable control circuits for operation of mechanical equipment.
- B. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACU 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 (LCD) 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.
- C. Circuits:
 - 1. Initiating Device Circuits: NFPA 72, Class B.
 - 2. Signaling Line Circuits: NFPA 72, Class B.
 - a. System Layout: Install no more than 20 addressable devices on each signaling line circuit complete with associated isolator module.
 - 3. Notification Appliance Circuits: NFPA 72, Class B.
 - 4. Actuation of alarm notification appliances and fire safety functions, annunciation, smoke control, elevator recall, and actuation of suppression systems shall occur within 10 seconds after the activation of an initiating device.
 - 5. Network Communications: NFPA Class A.
 - 6. Electrical monitoring for the integrity of wiring external to the FACU for mechanical equipment shutdown and magnetic door-holding circuits is not required, provided a break in the circuit will cause doors to close and mechanical equipment to shut down.
- D. Notification Appliance Circuit: Operation shall sound in a temporal code 3 pattern, complying with ANSI S3.41.
- E. Power Supply for Supervision Equipment: Supply for audible and visual equipment for supervision of the ac power shall be from a dedicated dc power supply, and power for the dc component shall be from the ac supply.
- F. Alarm Silencing, Trouble, and Supervisory Alarm Reset: Manual reset at the FACU after initiating devices are restored to normal.

1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
 3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.
- G. Walk Test: A test mode to allow one person to test alarm and supervisory features of initiating devices. Enabling of this mode shall require the entry of a password. The FACU and annunciators shall display a test indication while the test is underway. If testing ceases while in walk-test mode, after a preset delay, the system shall automatically return to normal.
- H. Remote Smoke Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and control of changes in 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 make a print-out of the final adjusted values on the system printer.
- I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, trouble, and supervisory signals to a remote alarm station through a digital alarm communicator transmitter and telephone lines.
- J. Service Modem: Ports shall be RS-232 for system printer and for connection to a dial-in terminal unit.
1. The dial-in port shall allow remote access to the FACU for programming changes and system diagnostic routines. Access by a remote terminal shall be by encrypted password algorithm.
- K. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events. Desk top printer.
- L. Primary Power: 24-V dc obtained from 120-V ac service and a power supply module. Initiating devices, notification appliances, signaling lines, trouble signal, supervisory and digital alarm communicator transmitter shall be powered by the 24-V dc source.
1. The alarm current draw of the entire fire alarm system shall not exceed 80 percent of the power supply module rating.
 2. Power supply shall have a dedicated fused safety switch for this connection at the service entrance equipment. Paint the switch box red and identify it with "FIRE ALARM SYSTEM POWER."
 3. System Power Supplies: Integral system power supplies shall provide 24VDC operating and

emergency power to each FACU and FPU (18 amps minimum to each panel). It is the design intent that all system power supplies to derive from network panels, and each power supply module shall have dedicated outputs and a charging circuit that will support up to 110AH batteries. Field located addressable notification appliance circuit modules or remote auxiliary power supplies will not be allowed, except where specifically shown on Drawings. The following system power supply analog values shall be available for viewing through the primary operator interface display:

- a. Battery voltage.
 - b. Battery charger voltage and current drawing.
 - c. Main output voltage (system 24 V) and current drawing.
 - d. Individual NAC current draw.
4. Auxiliary Power Supplies: Provide distributed network power supplies where shown. Power supplies shall communicate directly to the main Fire Alarm System via multiplexed communications to support network based synchronization, and supervision of each panel for ground fault, loss of AC power and Battery Fail. Each notification circuit served shall be individually supervised via on board circuitry.
- M. Secondary Power: 24-V dc supply system with batteries and automatic battery charger and an automatic transfer switch.
1. Batteries: Vented, wet-cell pocket, plate nickel cadmium.
 2. Battery and Charger Capacity: Comply with NFPA 72.
 3. Capacity: Per NFPA 72 and local codes.
- N. Surge Protection:
1. Install surge protection on normal ac power for the FACU and its accessories. Comply with Division 26 Section "Surge Protection Devices for Low-Voltage Systems" for auxiliary panel suppressors.
 2. Install surge protectors recommended by FACU manufacturer. Install on all system wiring external to the building housing the FACU.
- O. Operating 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.
- 2.6 FPU
- A. General Description:
1. Field processing unit is a remote network (extender) panel to FACU with identical requirements and centralized acknowledgements, drill switches and system resets required only at FACU.

2. The FPU(s) and FACU networked with each other to interface initiation and indicating functions as a peer-to-peer, token ring topology, network connected with a physically separated loop.
- B. FPU shall be microprocessor-based, housed in an all metal cabinet suitable for wall mounting, either flush or surface. Basic FPU size shall be sized to accommodate zoning and control functions as shown on fire alarm riser diagram plus a minimum of 25% spare capacity. Each FPU's microprocessor, memory, and associated circuitry shall have the ability to detect losses of communications with the FACU, resulting from defects in the communications circuit wiring.
- C. Sensing circuits from the FPU to peripheral devices shall be supervised to provide an indication of sensing circuit faults. Sensing circuit supervision shall not reduce available system monitor points. Sensing, circuits shall be capable of reporting an alarm, grounds, shorts, opens or trouble conditions. FPU sensing circuits shall be capable of working with normally open (N/C), or current limited normally open contacts, for Class A wiring and operation.
- D. FPU shall be equipped with an internal 24 VDC power supply and shall function as a completely independent system in event of a communications-line break with the FACU or a FACU failure. In the event of a communications or FACU failure, the local FPU shall receive and process monitor point inputs and shall initiate the appropriate control point actions. The local fire alarm annunciator shall function normally for all local zones.
1. If FPU to FACU communications failure, the FPU shall initiate audible alarms through its own redundant tone generators. The tone generators shall be sized for minimum 25 percent spare capacity above the sum of all devices at maximum tap settings.
 2. Tone speaker circuits shall have central redundant preamplifiers, amplifiers, and pre-recorded messaging and tone generators, located at the FACU, zoned through distributed amplifiers with addressable outputs at the FPU.
- E. Other Control Features/Functions Include:
1. Interface alarm inputs and control circuits outputs and communicate changes in operating status to the FACU.
 2. Communication between the FPU's and the FACU shall incorporate a BacNet Local Operating Network (LON) for easy wiring.
 3. The LON shall provide the interface for the Network Input/Output Nodes. The LON shall be a transformer isolated twisted pair network operating a 78.5K baud. Without any additional power boosters the LON shall be capable of wiring runs up to 2000 meters in length. Wiring runs in excess of 2000 meters shall be accomplished with the use of signal boosters.
 4. Provide continuous supervision of alarm input circuits and report alarm, opens or ground conditions.
 5. The FPU shall operate at 120V AC input with sufficient capacity to operate all alarm inputs and control circuit outputs. The FPU shall be provided with 25 percent spare capacity points.
 6. Batteries shall provide operating power to comply with NFPA 72. Batteries and charging circuitry shall be monitored and alarmed for battery failure (low charge or disconnected) or battery charger failure (high charge or system voltage failure).

7. FPU modules shall be card rack mounted, easily expanded, and contain sufficient capacity for all input and output functions as shown on Drawings.
8. Control circuit output relays shall be multiple, convertible contacts, 24V DC, 5A rating. Outputs shall be provided and coordinated for door release, HVAC shutdown, smoke dampers and auxiliary devices as shown on Drawings.
9. The FPU panel shall be interfaced with remote annunciator and FACU.

2.7 FATC

- A. Fire alarm terminal cabinets, as required, shall be surface mounted, labeled with "FIRE ALARM" nameplate, and shall contain screw type terminal strips as required for the wiring of the system as shown on Drawings. Provide cabinet size for amount of terminations and equipment modules required, including 10% spare capacity flush or surface mounted as shown on Drawings.

2.8 MANUAL PULL STATIONS

- A. Description: UL 38 listed; finished in red with molded, raised-letter operating instructions in contrasting color. Station shall show visible indication of operation. Mount on recessed outlet box; if shown on Drawings 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 the FACU.
 2. Station Reset: Key- or wrench-operated switch.
 3. Indoor Protective Shield: When shown on Drawings, provide 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.
 4. Weatherproof Protective Shield: When shown on Drawings, provide factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Weatherproof devices shall be non-addressable and rated for the intended equipment; monitored by an addressable module located in a conditioned space.

2.9 SYSTEM SMOKE DETECTORS

- A. General Description:
 1. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.
 2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 3. Remote Control: Detectors shall be analog-addressable type, individually monitored at the FACU for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACU.
 - a. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Sensor: LED or infrared light source with matching silicon-cell receiver.
2. Back-up Sensor: Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at the FACU to operate at 135 or 155 deg F (68 deg C) deg F (57 deg C).
3. Detector Photoelectric Sensitivity: Between 0.2 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
4. UL 268 listed, operating at 24-V dc, nominal.
5. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection of building wiring.
6. Local sonalert base audible alarm type as shown on Drawings containing the following:
 - a. Piezoelectric sounder rated at 88 dBA at 10 feet (3 m) according to UL 464.
7. Integral Visual-Indicating Light: Alarm/power LED type.

C. Duct Smoke Detector:

1. Photoelectric Smoke Detectors:
 - a. Sensor: LED or infrared light source with matching silicon-cell receiver.
 - b. Detector Sensitivity: Between 0.2 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
 - c. UL 268A listed, operating at 24-V dc, nominal.
 - d. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.
 - e. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.
 - f. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
 - g. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status. Provide remote status and alarm indicator and test station as shown on Drawings.
 - h. Remote Control: Detectors shall be analog-addressable type, individually monitored at the FACU for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACU.
 - i. Each sensor shall have multiple levels of detection sensitivity.
 - j. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.
2. Remote Duct Smoke Detector Test and Indication Station:

- a. Alarm/power LED on faceplate.
- b. Keyed.
- c. Flush ceiling mounted in finished areas and surface wall mounted or group wall mounted in equipment rooms.
- d. White lettering on red nameplate identifying associated detector(s).

2.10 NON-SYSTEM DETECTORS

A. Carbon Monoxide Detector:

1. UL 2075 listed, operating at 120V ac.
2. Auxiliary Relays: one Form C.
3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 404.
4. Test Switch: Push-to-test, simulates carbon monoxide at rated obscuration.
5. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm as one detector shall actuate notification on all connected detectors.
6. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
7. Self-Restoring: Detectors shall not require resetting as readjustment after activation to restore them to normal operation.
8. Suitable for mounting to flush junction box.

2.11 HEAT DETECTORS

- A. General: UL 521 listed selectable as fixed temperature or combination fixed/rate-of-rise operation as described herein. Heat detectors shall also be programmed as a low temperature utility sensor when ambient temperature drops below 40 degrees F. Heat detectors shall be of the bi-metal restorable type.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature and/or rate-of-rise of temperature that exceeds 15 deg F (8 deg C) or 20 degree F (11 degree C) selectable at the FACU per minute as shown on Drawings.
 1. Mounting: Plug-in base, interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.
- C. Heat Detector, Fixed Temperature Type: Actuated by temperature that exceeds a fixed temperature selectable as 135 degree F (57.2 degree C) or 155 degree F (68 degree C) as shown on Drawings.
 1. Mounting: Plug-in base, interchangeable with smoke-detector bases.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.
- D. Where ambient conditions preclude the use of addressable devices, equivalent conventional devices, rated for the environment shall be used. Each device shall be monitored by a dedicated addressable module located in a conditioned space.

2.12 DIGITAL ALARM COMMUNICATIONS TRANSMITTER (DACT)

- A. A DACT Unit shall be provided for each FACP. Each DACT provided shall be UL listed for Commercial Fire Alarm usage. Each DACT provided shall be equipped for dual phone lines with line-seizure, and shall be capable of transmitting the quantity of points specified within the "Operation" portion of this specification. Each DACT provided shall be field-configurable for transmission of several different non-proprietary formats.
- B. Each such DACT shall consist of a module, which shall be designed for mounting within the FACP wherever such DACT units are available, and wherever such DACT units meet the previously specified operational requirements.
- C. Where any DACT is not a listed component of the Fire Alarm Control Panel, such DACT units shall be provided within a separate metal enclosure, which shall be located adjacent to the associated FACP, unless specified otherwise. Such DACT units shall contain independent power supplies and batteries, which shall be sized in the same manner as the FACP batteries.

2.13 REMOTE ANNUNCIATOR

- A. The annunciator shall be supervised by the fire alarm panel and shall be UL listed for annunciator use with the fire alarm panel.
- B. The LCD display/control shall provide the following features:
 1. An 80 character alphanumeric display.
 2. Control Pushbutton Switches - For alarm silence, trouble silence and manual evacuation duplicating the control panel switches. A key "enable" switch shall be provided to activate or deactivate the control switches. Display shall not have a system reset button.
 3. Tone Alert - Duplicates the control panel tone alert during alarm and trouble conditions.
 4. System trouble LED.
 5. Power on LED.
 6. To accommodate and facilitate job site changes the control switches shall have the

capability to be programmed on site to provide for manual switch input operation other than their standard purpose.

- C. Annunciators shall be provided with a push to talk microphone and a system “all call” switch for fire department use. Systems which require any switch activation at the main FACP before using the remote microphones will not be accepted. Microphone requirements shall match that the FACP listed above.

2.14 FIRE ALARM NOTIFICATION APPLIANCES

- A. Description: Equipped for mounting generally as shown on Drawings and with screw terminals for system connections.
 - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.
- B. Audibility and Intelligibility Requirements:
 - 1. Suitable per NFPA 72 and local requirements.
 - 2. Be responsible to meet requirements using manufacturer specific notification appliances whose tap settings are generally set at the lower (1/2 watt) of their associated range and main power supplies and amplifiers with 25 percent minimum spare capacity above sum of all devices at maximum tap settings. Contract Drawing layouts depict generic industry solution approaches. Add notification appliances at no cost to Owner to meet these requirements. Submit design compliance per Pre-Installation Shop Drawing Submittal requirements.
 - 3. Design compliance to acknowledge the following minimum acoustical layout criteria:
 - a. Published anticipated average ambient room sound levels.
 - b. Loss of dBA for barriers:
 - 1) Stud/Drywall Walls: 35-50
 - 2) Doors: 15-20
 - 3) Drywall: 15-20
 - 4) Wall Coverings: 3-5
 - c. Space acoustical characteristics.
 - d. Speakers set at lower tap settings generally provide better intelligibility and more uniform sound levels.
 - e. Speakers in equipment rooms shall be set at minimum 2 watt tap setting.
 - f. Maximum occupant distance from a speaker is 50 feet.
- C. Tone Speakers:
 - 1. UL 1480 listed.
 - 2. General Type Low-Range Units: Rated 1 to 2 W.

3. Horn Type High-Range Units: Rated 2 to 15 W.
 4. Mounting: Flush, semi-recessed, or surface mounted; bidirectional as shown on Drawings. Flush ceiling speakers shall have round red grill. Surface ceiling speakers shall have backbox sized larger than grill.
 5. Matching Transformers: Tap range matched to the acoustical environment of the speaker location.
- D. Visible Alarm Devices: System synchronized xenon strobe lights listed under UL 1971, with clear polycarbonate lens mounted on faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
1. Rated Light Output: As shown on Drawings.
 2. Strobe Leads: Factory connected to screw terminals.
 3. Synchronization of strobes shall be accomplished via software programming systems that required field modules and synchronization circuits will be not considered acceptable.
 4. Unless indicated otherwise ceiling mounted devices shall be red.
 5. Unless indicated otherwise wall mounted devices shall be red.
- E. Notification Appliance Circuit (NAC) Extender Panel: The NAC extender panel shall function as a wiring termination and data collection point on each floor.
1. Provide notification appliance circuit capacity and synchronization for visible alarm devices. Size panel as required.
 2. The NAC extender panel may be mounted close to the host FACU or (FPU) or can be remotely located and shall connect to the host panel via a communications channel. Each output NAC can be individually controlled for general alarm or selective area notification as required by the area and function.
 3. Alarms from the host fire panel shall signal the NAC power extender panel to activate. The panel shall monitor itself and each of its NACs for trouble conditions and shall report trouble conditions to the host panel.

2.15 MAGNETIC DOOR AND GATE HOLDERS

- A. Supplied by Division 08, installed and wired by Division 28.
- B. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door/gate plate.
 1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
 2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
 3. Rating: Tri-voltage design to accommodate 12VDC, 24VDC, 24VAC or 120VAC
 4. Material and Finish: Match door hardware.

2.16 WATERFLOW ALARM, WATERFLOW SUPERVISORY TAMPER, AND DRY PIPE PRESSURE SWITCHES

- A. Supplied and installed by Division 21, wired by Division 28.

2.17 ADDRESSABLE RELAY

- A. Description: Microelectronic monitor module listed for use in providing a system address for listed alarm-initiating devices for hard-wired applications with auxiliary contacts such as non-system detectors, waterflow switches, tamper switches.
 - 1. Integral Relay: Provides a direct control signal for hard-wired applications with input contacts such as elevator recall, shunt trip, door release, smoke hatch release, fan shutdown, etc.
 - a. Minimum relay quantities for door releases shall be by floor (per FPU) to control all door releases in the area.
 - b. Provide individual relay for each auto operated door in a rated wall to automatically shunt power to unit during fire alarm.
 - 2. Relay modules shall be mounted flush in ceiling and be readily accessible and visible where located in finished spaces.

2.18 ADDRESSABLE RELAY MODULES CABINET

- A. Addressable modules, dependent on location, may, at Division 28 discretion, be mounted in cabinets in mechanical/electrical rooms for interaction/connection with room devices or be mounted as an integral part of the FPU cabinets.

2.19 WIRE GUARDS FOR PHYSICAL PROTECTION

- A. Description: Welded wire mesh of size and shape for the smoke detector, audible device, visual devices, or other device requiring protection as shown on Drawings.
 - 1. Construction and Finish: Per Division 26 Section "Wiring Devices."

2.20 WIRE AND CABLE

- A. Wire and cable for fire alarm systems shall be UL listed and labeled as complying with NFPA 70, Article 760.
 - 1. Limit circuit voltage drop to 10 percent maximum.
- B. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG size as recommended by system manufacturer.
- C. Circuit Integrity Cable: Twisted shielded pair, NFPA 70 Article 760, Classification CI, for power-limited fire alarm signal service. UL listed as Type FPL, and complying with requirements in UL 1424 and in UL 2196 for a 2-hour rating.
 - 1. Notification appliance circuits passing through a separate fire zone shall be 2-hour rated per UL 2196.

2. Backbone communication circuits between FACU and FPU's shall be 2-hour rated per UL 2196.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 1. Low-Voltage Circuits: No. 18 AWG, minimum.
 2. Line-Voltage Circuits: No. 12 AWG, minimum.
 3. Multiconductor Armored Cable: NFPA 70 Type MC, copper conductors, TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, UL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.
- E. Fire alarm cable shall be red in color with label/printing appropriate for the application; refer to Division 26 Section "Electrical Identification:

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Connecting to Equipment:
 1. Connect new equipment to the control panel.
 2. Connect new equipment to the monitoring equipment at the Supervising Station.
 3. Ensure proper system operation and code compliant system operation all the time.
- B. Install equipment mounting heights in accordance with State, Local Fire Alarm Codes, and Handicapped Codes.
- C. Install devices being conscious of exact placements per NFPA 72. The Drawings are diagrammatic.
- D. Install device boxes of size and type recommended by manufacturer's representative to suit device and location shown on Drawings. Paint boxes per Division 26 Section "Boxes and Cabinets". Install FPU, NAC extender panel and FATC cabinets at five feet above floor to center, unless otherwise noted, supported independently from stud partitions.
- E. Install minimum quantity of FPU's and FATC's; as shown on Drawings to meet survivability and wiring homerun design intent.
- F. Overcurrent device location shall be identified with appropriate nameplate at the FACU's, FPU's, NACs, Audio Amplifiers and all other fire alarm power supply units. Refer to Division 26 Section "Electrical Identification". Provide breaker handle clips in on position and "Fire Alarm System" nameplate at all panelboard breakers serving the fire alarm equipment.
- G. Place batteries in the FACU, FPU's or similar type enclosure located next to the control unit. Batteries which vent explosive hydrogen gas (gelled-electrolyte, lead-calcium, lead-antimony, and nickled-cadmium) shall not be placed in the same enclosure as the fire alarm control panel. Such batteries shall be placed in an area with suitable ventilation. It shall be the responsibility of the fire alarm supplier to advise the engineer and contractor at bid time of any special ventilation requirements not provided as part of the fire alarm contract.
 1. Provide framed glass print of appropriate zoning diagram adjacent to each FACU and FPU.

H. System Smoke or Heat Detector Spacing:

1. Smooth ceiling spacing shall not exceed 30 feet (9 m).
2. Spacing of heat detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas, shall be determined according to Appendix A in NFPA 72.
3. Spacing of heat detectors shall be determined based on guidelines and recommendations in NFPA 72.
4. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
5. Mount detector bases on ceiling boxes such that the indicator lamps are visible from the floor below (lined up in corridor applications) or from the nearest equipment aisle or from the doorway entering the room.

I. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of the duct and are mounted near the top third on the side of a duct. Provide remote duct smoke detector test station for each duct smoke detector.

J. Locate fan shutdown control modules within three (3) foot of associated fan controller, unless hardwired to local FPU. In either case, an individual addressable alarm point is required.

3.2 WIRING INSTALLATION

A. Install wiring according to the following:

1. NECA 1.
2. TIA/EIA 568-A.
3. Division 26 and 27 Sections "Raceways and Boxes" and "Pathways"

B. Raceways: Where installed in metallic raceways conform to Division 26 Section "Raceways."

1. Fire alarm circuits and equipment control wiring associated with fire alarm system shall be installed in solid colored conduit system per division 26 "Raceways". Cabling shall be installed in conduit where exposed to physical damage.
2. Where installed in conduit, fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
3. Size raceways and associated boxes as required by the National Electrical Code limiting fill to 30 percent unless otherwise indicated or further reduced by manufacturer's representative's recommendations. Terminate all conduits with plastic bushings.
4. Connect all devices mounted on suspended ceilings to securely mounted junction boxes with enough wiring to move the device five (5) feet in any direction.
5. Fire alarm conduit shall be red in color; refer to Division 26 Section "Electrical Identification".

C. Wiring Method:

1. Provide interconnecting wire and cable between the various system devices for proper system operation as recommended by the manufacturer's representative.
 2. Cables and raceways 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: Provide 2-hour fire rated fire alarm cables, NFPA 70 Type MI, NFPA 70 Type CI with associated metallic conduit to meet 2-hour rating, or 2-hour enclosure for:
 - a. Looped backbone FPU communication risers.
 - b. Notification appliance circuits until they enter the evacuation signaling zone that they serve.
 - c. Class A return loop when passing through separate fire zone(s).
 4. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.
 5. Provide push-in wire connectors and make splice connection to each device to facilitate device maintenance.
- D. 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.
- E. Cable Terminations: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and a different color code 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 raceway couplings, junction boxes and covers red. Provide red colored conduit.
- G. Backbone FPU Communication Risers: Install at least two vertical 2-hour fire-rated fire alarm cable risers to serve the fire alarm system. Separate risers physically minimum 40 foot apart in separate rooms.
- H. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the FACU and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.
- 3.3 IDENTIFICATION
- A. Identify system components, wiring, cabling, and terminals according to Division 26 Section "Electrical Identification."
 - B. Install framed operating instructions in a location visible from the FACU.
 - C. Paint power-supply disconnect switch red and label "FIRE ALARM."

- D. Mark each addressable device with system device address per Owner requirements. Obtain inspecting tags from owner or owner's vendor. Labels shall be legible when viewed from the floor without the need for a ladder.

3.4 GROUNDING

- A. Ground the FACU and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACU.
- B. Ground equipment and conductor and cable shields. For audio circuits, minimize to the greatest extent possible group loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to supervise field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72.
 - 2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72. Certify compliance with test parameters. All tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level III.
 - 3. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.
 - 4. Testing: Follow procedure and record results in the form of a record of completion complying with requirements in NFPA 72.
 - a. Detectors that are outside their marked sensitivity range shall be replaced.
 - 5. Test and Inspection Records: Prepare according to NFPA 72, including demonstration of sequences of operation by using the matrix-style form in NFPA 72.
- C. Repeat the complete field tests and inspections of the entire system at the 11 month point of the one year warranty period.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.
- B. Follow-Up Tests and Inspections: After date of Substantial Completion, test the fire alarm system complying with testing and visual inspection requirements in NFPA 72.

3.7 SYSTEM CERTIFICATION AND TESTING DOCUMENTATION

- A. Submit written certification documenting successful completion of all system required testing. This certification and documentation shall include certification that the system:
1. Has been visually inspected and functionally tested by a manufacturer's certified representative. Documentation shall include:
 - a. The date and time of each test.
 - b. A reference set of record drawings, numerically identifying the individual components and circuits tested.
 - c. A description of each test/verification performed.
 - d. A checklist of each device and circuit test, indicating the results of each test. Include speaker tap setting list and initiating device time/sensitivity setting list.
 - e. A narrative sequence of operations for all associated evacuation signaling and auxiliary functions, including a verification checklist documenting correct operation.
 - f. The names and signatures of the individuals conducting and witnessing each test.
 - g. A checklist of test results for signaling between related systems including:
 - 1) Division 23 BAS for fan shutdown, damper, and smoke control.
 - 2) Division 14 elevator recall and shutdown.
 - 3) Division 21 fire pump signaling.
 - 4) Division 21 fire suppression signaling.
 - 5) Division 21 fire protection signaling.
 - 6) Division 08 for hardware interface such as door and smoke hatch releases.
 - 7) Security system signaling for door release(s).
 2. Is installed entirely in accordance with the manufacturer's recommendations and within the limitations of the required listings and approvals.
 3. Is in proper working order and in full compliance with Contract Documents.
 4. Has latest version of manufacturer's software and graphics. Include appropriate listing.
- B. Note: Multiple tests may be required depending upon approval of suggested Division 28 phasing.

3.8 RECORD DRAWINGS

- A. Upon completion of the installation, record drawings shall be submitted on each system before final acceptance of the work. Furnish to the Engineer a set of record drawings including system diagrams for each system. The record drawing masters shall be on reproducible Mylar film. Uniformly sizes as required for legibility and reproduction and on high density floppy disks in latest Autocad Version format. (Note that contract document drawings are available from the Architect on floppy disk for a negotiated fee.) Record drawings shall illustrate all peripheral device locations including final address, major equipment locations,

zoning, conduit routing, single line riser diagram depicting wiring characteristics and termination designations for all devices. Also included shall be documentation of spare raceways.

3.9 TRAINING

- A. For new facilities provide the services of a factory authorized service representative to demonstrate and train the facilities maintenance personnel as specified below.
- B. Train facilities maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintenance of the system. Training shall also include complete user software/graphics changeability by Staff Personnel. Provide a minimum of 4-hour training session for ten (10) facility staff total.
- C. The session shall be videotaped with 2 DVD copies turned over to the Owner upon completion. Include:
 - 1. Permanent training manuals as well as ten (10) individual training manuals broken apart by training session.
 - 2. All costs associated with training at the facility in a classroom environment.
 - 3. An hourly rate for training beyond the specified sessions shall be presented to the Owner.
 - 4. All standard manufacturer training video tapes and manuals as part of permanent training manuals.
- D. Coordinate and schedule training with the facility at least one month in advance.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the fire alarm system, appliances, and devices. Refer to Division 01 Section "Demonstration and Training."

A. Standard non-smoke purge air handling systems:

REGULAR AHU											
FIRE ALARM AND MECHANICAL CONTROLS MATRIX											
EVENT (DEVICE ACTIVATED)	CONTROLLED RESPONSES PER SYSTEM										NOTES
	SUPERVISORY SIGNAL VIA FIRE ALARM* (NFPA 99 15.7.4.2.2, NFPA 90A 6.4.4.2.1 & NFPA 101 9.6.3.2.2)	TROUBLE SIGNAL VIA FIRE ALARM	ALARM SIGNAL VIA FIRE ALARM	SMOKE PURGE MODE VIA FIRE ALARM*** (NFPA 90A 6.4.3.2)	SHUT DOWN FANS VIA FIRE ALARM (NFPA 90A 6.4.3.1)	CLOSE LOCAL DAMPER ASSOCIATED WITH DUCT DETECTOR***	CLOSE ALL SMOKE DAMPERS VIA FIRE ALARM (NFPA 90A 6.3.3 & IBC 716.3.3.2)	CLOSE THE AHU RETURN CONTROL DAMPER VIA BAS	VAV SETTING FOR ROOM WHICH DETECTED SMOKE, SET VIA BAS	VAV SETTINGS FOR ALL OTHER ROOMS, SET VIA BAS	
CORRIDOR SMOKE DETECTOR			X						NORMAL	NORMAL	
OTHER AREA SMOKE DETECTOR			X						NORMAL	NORMAL	
SMOKE DETECTORS USED IN LIEU OF DUCT DETECTORS** (IBC 716.3.3.2)			X			X			NORMAL	NORMAL	
DUCT DETECTORS REMOTE OF THE AHU (SUPPLY & RETURN)	X					X			NORMAL	NORMAL	CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
DUCT DETECTOR(S) AT AHU RETURN	X				X	X	X		NORMAL	NORMAL	CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
DUCT DETECTOR(S) AT AHU SUPPLY	X				X	X	X		NORMAL	NORMAL	CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
IF AHU SERVES MULTIPLE FLOORS, DUCT DETECTORS AT SHAFT WALLS OR FLOOR PENETRATIONS.	X				X	X	X		NORMAL	NORMAL	CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
AHU OFF FOR ANY REASON							X		NORMAL	NORMAL	

* TWO SUPERVISORY SIGNALS, WITHIN THE SAME BUILDING OR A BUILDING WHICH SHARES A FIRE ALARM PANEL, WOULD INITIATE A FIRE ALARM SEQUENCE.

** IF APPLICABLE, THIS WILL BE EVALUATED ON A CASE BY CASE BASIS

*** SYSTEM NEEDS TO BE EVALUATED TO ENSURE DUCTWORK PRESSURE IS REGULATED PROPERLY WITHOUT SHUTTING DOWN UNIT.

B. Exhaust Fans:

EXHAUST FANS FIRE ALARM AND MECHANICAL CONTROLS MATRIX											
EVENT (DEVICE ACTIVATED)	CONTROLLED RESPONSES PER SYSTEM										NOTES
	SUPERVISORY SIGNAL VIA FIRE ALARM* (NFPA 99 15.7.4.2.2, NFPA 90A 6.4.4.2.1 & NFPA 101 9.6.3.2.2)	TROUBLE SIGNAL VIA FIRE ALARM	ALARM SIGNAL VIA FIRE ALARM	SMOKE PURGE MODE VIA FIRE ALARM*** (NFPA 90A 6.4.3.2)	SHUT DOWN FANS VIA FIRE ALARM (NFPA 90A 6.4.3.1 & 6.4.2.3)	CLOSE LOCAL DAMPER ASSOCIATED WITH DUCT DETECTOR***	CLOSE ALL SMOKE DAMPERS VIA FIRE ALARM ***** (NFPA 90A 6.3.3 & IBC 716.3.3.2)	CLOSE THE AHU RETURN CONTROL DAMPER VIA BAS	VAV SETTING FOR ROOM WHICH DETECTED SMOKE, SET VIA BAS	VAV SETTINGS FOR ALL OTHER ROOMS, SET VIA BAS	
ANY DUCT DETECTOR WITHIN EXHAUST SYSTEM	X					X					CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
SMOKE DETECTORS USED IN LIEU OF DUCT DETECTORS** (IBC 716.3.3.2)			X			X					CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
ANY SMOKE DETECTOR IN ROOM(S) SERVED BY FAN			X								CODE ALLOWS EITHER SUPERVISORY OR ALARM SIGNAL
FAN OFF FOR ANY REASON							X				
THIS MATRIX IS APPLICABLE ONLY FOR EXHAUST FANS PER NFPA 90A (2009), NFPA 99(2009), IB(2009) AND IMC (2009).											
* TWO SUPERVISORY SIGNALS, WITHIN THE SAME BUILDING OR A BUILDING WHICH SHARES A FIRE ALARM PANEL, WOULD INITIATE A FIRE ALARM SEQUENCE.											
** IF APPLICABLE, THIS WILL BE EVALUATED ON A CASE BY CASE BASIS.											
*** SYSTEM NEEDS TO BE EVALUATED TO ENSURE DUCTWORK PRESSURE IS REGULATED PROPERLY WITHOUT SHUTTING DOWN UNIT.											
**** REFER TO SMOKE PURGE SYTEM SEQUENCE ON THE DRAWINGS.											

END OF SECTION

SECTION 31 10 00 - SITE CLEARING

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. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing, removing site utilities or abandoning site utilities in place.
7. Temporary erosion- and sedimentation-control measures.

B. Related Sections:

1. Division 01 Section "Execution" for field engineering and surveying.
2. Division 01 Section "Construction Waste Management and Disposal" for disposal of demolished materials.
3. Division 02 Section "Structure Demolition" for demolition of buildings, structures, and site improvements.
4. Division 32 Section "Temporary Erosion- and Sedimentation-Control Measures".
5. Appendix A - Geotechnical Data.

1.3 DEFINITIONS

- A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.
- D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and

black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

- E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
- F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings and defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated.
- G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
 - 1. Use sufficiently detailed photographs or videotape.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.
- B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

- A. Preinstallation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

- B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Do not proceed with work on adjoining property until directed by Architect.
- C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises.
- D. Utility Locator Service: Notify Digger (Chicago Area Alert Network) at 312-744-7000 Forty Eight hours before excavation/demolition to have the location of existing underground utilities marked or staked.
- E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
- F. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- G. Do not direct vehicle or equipment exhaust towards protection zones.
- H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.
- I. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."
 - 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly identify trees, shrubs, and other vegetation to remain.
- C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction, including but not limited to, UIC, EPS, NPDES, NCRS, and the City of Chicago.
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. General: Protect trees and plants remaining on-site according to requirements in Division 01 Section "Temporary Tree and Plant Protection" and per UIC Grounds requirements.
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Architect.

3.4 EXISTING UTILITIES

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
 1. Contractor to notify and request from UIC Utilities and UIC Project Manager any utility shut downs by a minimum of 72 hours prior to any required utility shut-down.
 2. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
 1. Arrange with utility companies to shut off indicated utilities.
 2. Owner will arrange to shut off indicated utilities when requested by Contractor.
- C. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 1. Notify Owner not less than 5 days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Owner's written permission.

- E. Excavate for and remove underground utilities indicated to be removed.
- F. Removal of underground utilities is included in Division 33 Sections.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
 - 3. Use only hand methods for grubbing within protection zones.
 - 4. Chip removed tree branches and dispose of off-site.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to a minimum depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
 - 1. Limit height of topsoil stockpiles to 72 inches.
 - 2. Do not stockpile topsoil within protection zones.
 - 3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
 - 4. Stockpile surplus topsoil to allow for resspreading deeper topsoil.

3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 10 00

SECTION 31 20 00 - EARTH MOVING

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. Preparing subgrades for slabs-on-grade walks pavements turf and grasses and plants.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for concrete slabs-on-grade.
4. Subbase course for concrete walks and pavements.
5. Subbase course and base course for asphalt paving.
6. Subsurface drainage backfill for and trenches.
7. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Sections:

1. Division 01 Section "Photographic Documentation" for recording pre-excavation and earth moving progress.
2. Division 01 Section "Construction Waste Management and Disposal" for disposal of demolished materials.
3. Division 03 Section "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
4. Division 33 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures.
5. Division 31 Section "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
6. Division 32 Section "Exterior Plants and Soil" for finish grading in planting areas and tree and shrub pit excavation and planting.
7. Division 33 Section "Subdrainage" for drainage of slabs-on-grade.
8. Appendix A – Geotechnical Data

1.3 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
 - 1. Geotextiles.
 - 2. Controlled low-strength material, including design mixture.
 - 3. Warning tapes.
- B. Samples for Verification: For the following products, in sizes indicated below:
 - 1. Geotextile: 12 by 12 inches
 - 2. Warning Tape: 12 inches; of each color.
- C. Qualification Data: For qualified testing agency.

- D. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487.
 - 2. Laboratory compaction curve according to ASTM D 698.
- E. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

1.5 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.
- B. Preexcavation Conference: Conduct conference at Project site.

1.6 PROJECT CONDITIONS

- A. Subsurface soil investigations and earthwork recommendations have been made and a report is included in the Specifications under Appendix A – Geotechnical Data to inform the Contractor of the type and character of materials expected to be encountered. Refer to:
 - 1. Report of Pavement Section Exploration, University of Illinois-Chicago Parking Lots 1A and 1B, Chicago, IL dated June 10, 2015 as prepared by Midland Standard Engineering & Testing, Inc. (Project No. 15238).
 - 2. Soil reports and data are made available for the convenience of the Contractor. It is recognized that any subsurface investigation may not disclose all conditions as actually exist and conditions may change, particularly groundwater conditions, between the time of subsurface investigation and the time of earthwork operations.
- B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- C. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Do not proceed with work on adjoining property until directed by Architect.
- D. Utility Locator Service: Notify Digger (Chicago Area Alert Network) at 312-744-7000 Forty Eight hours before excavation/demolition to have the location of existing underground utilities marked or staked.
- E. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Division 31 Section "Temporary Erosion- and Sedimentation-Control Measures" are in place.

- F. Do not commence earth moving operations until plant-protection measures specified in Division 01 Section "Temporary Tree and Plant Protection" are in place.
- G. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- H. Do not direct vehicle or equipment exhaust towards protection zones.
- I. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
 - 1. Liquid Limit: 45 or less.
 - 2. Plasticity Index: 20 or less.
- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch and not more than 12 percent passing a No. 200e.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch and not more than 8 percent passing a No. 200e.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch and not more than 12 percent passing a No. 200e.

- G. Bedding Course: Meeting IDOT certified CA-11 gradation.
- H. Utility Trench Backfill: Meeting IDOT certified FA-6 or CA-7 gradation
- I. Drainage Course: Meeting IDOT certified CA-7 gradation.
- J. Low Permeability Choker Coarse Material: Meeting IDOT certified CA-6 gradation.
- K. Sand: ASTM C 33; fine aggregate.
- L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polypropylene or polyesters; measured per test methods referenced:

Physical Property Requirements

Test	Non-woven
Grab Tensile Strength (ASTM D-4632)	120 lbs.
CBR Puncture Strength (ASTM D-6241)	310 lbs.
Trapezoid Tear Strength (ASTM D-4533)	50 lbs.
Apparent Opening Size (ASTM D-4751)	70 US Sieve
Permittivity (ASTM D-4491)k	1.50 sec ⁻¹
Ultraviolet Degradation @ 500 hours (ASTM D-4355)	70% min.

2.3 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches and 4 mils, continuously inscribed with a description of the utility; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches and 4 milsk, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
- B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
 - a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.6 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
 1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
 2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
 3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
 4. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- D. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
 1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- E. Trenches in Tree- and Plant-Protection Zones:
 1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree and Plant Protection."

3.7 SUBGRADE INSPECTION

- A. Notify Architect when excavations have reached required subgrade.
- B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.8 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.
 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.11 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill voids with satisfactory soil while removing shoring and bracing.
- D. Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- E. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.
- F. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- G. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.12 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
1. Under grass and planted areas, use satisfactory soil material.
 2. Under walks and pavements, use satisfactory soil material.

3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.13 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.14 GENERAL EARTHWORK REQUIREMENTS

- A. **Appendix A** – Geotechnical Data, shall be followed for all earthwork operations. The exposed subgrade should be graded per plan and compacted to enhance the lot permeability characteristics desired to reduce the potential for water infiltrate and saturate the underlying soils. A minimum compacted density of 95% per ASTM D 698 should be achieved. The compacted subgrade should be immediately capped with the 4" thick Low Permeability Choker Course to seal off the subgrade soils.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 9 percent.
 3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
 4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 - 1. Turf or Unpaved Areas: Plus or minus 1 inch.
 - 2. Walks: Plus or minus 1 inch.
 - 3. Pavements: Plus or minus 1/2 inch.

3.17 SUBSURFACE DRAINAGE

- A. Subdrainage Pipe: Specified in Division 33 Section "Subdrainage."
- B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
 - 1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
- C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
 - 1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
 - 2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course under pavements and walks as follows:
 - 1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place base course material over subbase course under hot-mix asphalt pavement.
 - 3. Shape subbase course to required crown elevations and cross-slope grades.
 - 4. Place subbase course 6 inches or less in compacted thickness in a single layer.

5. Place subbase course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
6. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.19 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 2. Place drainage course 6 inches or less in compacted thickness in a single layer.
 3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.20 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 2. Determine that fill material and maximum lift thickness comply with requirements.
 3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
 1. Paved : At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area, but in no case fewer than three tests.
 2. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.21 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
 - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00

SECTION 31 29 08 - FINAL SHAPING, GRADING AND SITE RESTORATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the requirements for final shaping, trimming and finishing. The work under this Section includes furnishing all labor, tools, materials, and equipment required to complete the final finishing and cleaning up the entire construction site including the private property and otherwise completing the work for acceptance.
- B. RELATED DOCUMENTS: Related work specified, elsewhere includes:
 - 1. Section 013200 "Construction Procedures"
 - 2. Section 312040 "Existing Utilities"
 - 3. Section 312360 "Excavating, Backfilling And Compaction"
 - 4. Except as modified herein, the work shall conform to the applicable portions of the Standard Specifications, Section 212.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 31 29 08

SECTION 32 12 16 – ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section specifies the requirements for constructing the hot-mix asphalt surface courses as detailed in the Drawings for street repairs and patching. The work shall include furnishing all labor, materials, tools, and equipment as required for the construction of the prime coat and hot-mix asphalt surface course.
- B. Related Sections:
 - 1. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications". Except as modified herein, the work shall conform to the applicable portions of the Standard Specifications, Section Sections 403 and 406". Articles of the Standard Specifications covering "Method of Measurement" and "Basis of Payment" are not applicable.
 - 2. Division 31 Section "Earth Moving".

1.3 SUBMITTALS

- A. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- B. Contractor shall submit to the Engineer plant certification for the hot-mix asphalt supplier along with the proposed mix design for approval prior to any surfacing operations.

PART 2 - PRODUCTS

2.1 MIXES

- A. Recycled Content of Hot-Mix Asphalt: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 20 percent or more than 25 percent by weight.
 - 1. Surface Course Limit: Recycled content no more than 10 percent by weight.

2.2 SURFACE COURSE

- A. On Site:
 - 1. Surface course shall be Hot-Mix Asphalt Surface Course, Mixture D, IL-9.5, $N_{des} = 50$.
- B. Off-Site:
 - 1. Asphalt Surface course per CDOT standards and specifications.

2.3 BINDER COURSE

- A. On-Site:
 - 1. Binder course shall be Hot-Mix Asphalt Binder Course, IL-19.0, $N_{des} = 50$.
- B. Off-Site:
 - 1. Asphalt Binder course per CDOT standards and specifications.

2.4 PRIME COAT

- A. Bituminous material (Prime Coat) shall be as specified in Article 403.02 of the Standard Specifications

PART 3 - EXECUTION

3.1 DENSITY MEASUREMENTS

- A. The Owner's Testing Agency density measurements shall be taken during the placement of both courses to insure proper compaction. If measurements show a failure to meet the compaction requirements, the Contractor shall adjust his/her compacting operations in accordance with Article 406.07 of the Standard Specifications.

3.2 PRIME COAT APPLICATION

- A. Bituminous prime coat shall be applied in accordance with Articles 403.09 & 406.05 of the Standard Specifications.

END OF SECTION 32 12 16

SECTION 32 12 36 - ASPHALT SEALCOAT

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Asphalt sealcoat.

1.02 REFERENCE STANDARDS

- A. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates; 2014.
- B. ASTM D244 - Standard Test Methods and Practices for Emulsified Asphalts; 2009.
- C. ASTM D2939 - Standard Test Methods for Emulsified Bitumens Used As Protective Coatings; 2003.
- D. ASTM D6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements; 2015.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting not less than 2 weeks prior to the start of the work of this section.
 - 1. Ensure required submittals have been provided with sufficient time for review prior to scheduling the Preinstallation Meeting.
 - 2. Review the detailed requirements for the work of this section and to review the drawings and specifications for this work
 - 3. Require attendance by all affected installers including but not limited to
 - a. Contractor's Superintendent
 - b. Installer
 - c. Manufacturer/Fabricator Representative
 - d. Other affected Subcontractors
 - e. Architect/Engineer of Record
 - f. Board's Representative
 - 4. Record minutes and distribute copies within 5 days after meeting to participants as well as Architect/Engineer of Record, Board and those affected by decisions made.
- B. Review the construction schedule, availability of materials, Installer's personnel qualifications, equipment, and facilities needed to make progress and avoid delays, existing conditions regarding pavement, installation procedures, testing and inspection procedures, traffic restrictions, and coordination with other work.
- C. Conference shall include Contractor, Architect/Engineer of Record, Board's Representative, sealcoat installer, sealcoat manufacturer's technical field representative, and any other subcontractors or materials technical field representatives whose work must be coordinated with the sealcoat work.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Include technical data and tested physical and performance properties.
 - 2. Include cure time, based on mix design for the Project.

- B. Samples: For each pavement marking product and for each color and texture specified; on rigid backing, 12-inches by 12-inches.
- C. Qualification Data: For Installer.
- D. Manufacturer Certifications:
 - 1. Submit letter, signed by authorized representative of manufacturer, certifying the sealcoat products are acceptable for application intended and Project conditions.
 - 2. Submit letter, signed by authorized representative of manufacturer, certifying the crack/joint sealant and sealcoat products are compatible with one another, based on recent testing by an independent testing agency.
- E. Field Reports: Submit field reports prepared by manufacturer's technical field representative.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Products shall be provided from a manufacturer that specializes in the production of asphaltic materials, including sealcoats, with not less than five (5) years' experience.
- B. Installer Qualifications: Engage an experienced Installer, who is authorized or approved in writing by the sealcoat product manufacturer(s), who has completed not less than three (3) sealcoat applications over the last five (5) years that were similar in material, design, and extent to that indicated for the project and which have resulted in installations with a record of successful in-service performance. Provide reference project names, locations, completion dates, names and telephone numbers of each project's Architect and Owner.
 - 1. The Installer shall employ only skilled tradesmen who are thoroughly experienced with the materials and equipment to be used for the Work. The Installer shall maintain a full-time supervisor/foreman who is on the Site during the time the sealcoat work is in progress and who is experienced in installing sealcoat systems similar to type required for the Project.
- C. Source Limitations: Obtain primary sealcoat materials from a single manufacturer. Provide other products as recommended by manufacturer of primary products for use with the sealcoat materials to be applied.
- D. Regulatory Requirements: Comply with requirements of authorities having jurisdiction in regards to application of, and disposal of excess, sealcoat materials, including stormwater pollution prevention requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original unopened containers, with manufacturer's original labels identifying manufacturer's name, product name, and directions for storing and handling.
- B. Coordinate delivery of materials to minimize need for on-site storage and to avoid delays in the Work.
- C. Store aggregate materials in a clean and dry location, under cover, protected from precipitation and direct sunlight, on elevated platforms where contamination can be avoided. Do not use aggregates that have become damp.
- D. Store sealcoat materials within the temperature range required by the manufacturer.

1.07 FIELD CONDITIONS

- A. Do not apply sealcoat materials if asphalt pavement is wet or excessively damp, if rain is imminent or expected before time required for adequate cure or 24 hours following application, whichever is greater.
- B. Apply sealcoat materials to asphalt pavement surfaces that are not less than 50 deg F at time of application and anticipated to remain above 50 deg F for not less than 12 hours following time of application.
- C. Apply sealcoat materials when ambient air temperature is 50 deg F and rising, but less than 85 deg F, and forecasted to remain above 50 deg F for not less than 48 hours following application.
- D. Ambient air temperatures shall be measured in the shade, away from paved surfaces and other artificial sources of heat.

1.08 WARRANTY

- A. Special Warranty: Submit a written warranty, executed by the Contractor, Installer, and manufacturer of sealcoat products agreeing to remove and replace, or repair, areas of the sealcoat installations that develop defects in materials or workmanship within the specified warranty period. Defects include abnormal wear, beyond that attributed to anticipated traffic volume, flaking, chipping, loss of adhesion, and tracking to adjacent areas and surfaces.
 - 1. Warranty Period: Two (2) years from date of Preliminary Acceptance.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
 - 1. The Brewer Company; Milford, OH.
 - 2. Neyra Industries, Inc.; Cincinnati, OH.

2.02 MATERIALS

- A. Sealcoat: Polymer modified asphalt emulsion sealcoat complying with ASTM D2939 and ASTM D244; containing no coal tar; and containing less than 10 g/L volatile organic compounds (VOC's).
- B. Aggregate: Water-washed and dried, angular silica sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof; free of clay, organic material, and other deleterious substances.
 - 1. Gradation: Aggregate shall have a 40-70 AFS grain fineness number when tested in accordance with ASTM C136/C136M.
- C. Water: Potable and free of harmful soluble salts; not less than 50 deg F.
- D. Primer - Pavement: Rapid drying, water-based emulsion formulated for application over aged asphalt pavement, and that promotes adhesion of applied sealcoat. As recommended by sealcoat manufacturer for each application indicated and Project conditions, and compatible with applied sealcoat.
- E. Primer - Oil Spot: Rapid drying, water-based emulsion formulated to seal and enhance adhesion over oil, grease, gasoline, and other fluid or chemical spots or stains. As recommended by sealcoat

- F. Joint Sealant: ASTM D6690, Type II or III, hot-applied, single-component, polymer-modified bituminous sealant.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with sealcoat manufacturer's requirements for conditions affecting sealcoat installation.
- B. Verify that existing asphalt paving is dry and free of irregularities, defects, vegetation, and substances, including vehicular oils, fuels, or other fluids, that may adversely affect adhesion of sealcoat.
 - 1. Defects include, but are not limited to, alligator cracking, rutting, depressions, ridging, and potholes.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Repairs to asphalt pavement shall be performed according to requirements in Section 32 12 16 - Asphalt Paving.

3.02 PREPARATION

- A. Remove existing wheel stops, traffic calming devices, and ground-mounted signage. Store in protected location until reinstalled or replaced as indicated.
- B. Provide surface-applied protection over surface catch basins, drains, manholes, and similar items that are not to receive sealcoat.
- C. Protect adjacent curbs, fences, sidewalks, driveways, and other surfaces from application of primers and sealcoat.
- D. Remove surface spots of oil, gas, grease, and other fluids - use household cleaner only as recommended by sealcoat manufacturer. Identify stained areas where oil spot primer is to be applied.
- E. Crack and Joint Filling:
 - 1. General: Comply with sealcoat manufacturer's written instructions regarding preparation, including routing, of cracks and joints in existing asphalt pavement.
 - 2. Remove all vegetation, dirt, debris, and loose material from cracks and joints.
 - 3. Ensure edges of cracks and joints are dry. Remove wetness from surfaces of cracks and joints.
 - 4. Clean cracks and joints in existing hot-mix asphalt pavement. Remove existing joint sealant and rout cracks and joints as recommended by sealcoat manufacturer.
 - 5. Cracks and joints less than 1/4-inch wide shall be routed to not less than 1/2-inch wide by 1/2-inch deep. Clean routed joints and cracks of debris and loose material.
 - 6. Use hot-applied joint sealant to seal cracks and joints more than 1/4-inch wide, including routed cracks and joints. Fill flush with surface of existing pavement and remove excess.
- F. Immediately before placing primers and sealcoat materials, remove dust, dirt, and other loose foreign materials, mud and other lightly adhered materials, and debris from surface of asphalt pavement with air blower, power sweeper, or brooms. Water washing or flushing shall not be allowed unless approved in writing by primer manufacturer.

- G. Asphalt pavement to receive sealcoat shall be prewetted with clean water as recommended by manufacturer.

3.03 PRIMER APPLICATION

- A. Prepare and thoroughly mix oil spot and asphalt primers in accordance with manufacturer's written instructions. Mix during use/application as recommended by manufacturer.
- B. Apply primers with equipment, and at application rates, recommended by manufacturer for the condition of the asphalt pavement, including staining, to be sealed.
- C. Apply primer over hot-applied joint sealant as recommended by manufacturer.

3.04 SEALCOAT APPLICATION

- A. Prepare and thoroughly mix pavement sealcoat in strict accordance with manufacturer's written instructions to achieve homogeneous mix and consistency recommended by manufacturer for condition of asphalt pavement.
 - 1. Add water to sealcoat mix as recommended by manufacturer to achieve fluid consistency required to uniformly coat asphalt pavement at application rate recommended by manufacturer for the Project.
 - 2. Add aggregate to sealcoat mix at rate recommended by manufacturer for the Project. Thoroughly mix aggregate into emulsion with power equipment to achieve homogeneous mixture with aggregate evenly distributed throughout, without clumping, and thoroughly coated.
- B. Apply sealcoat mix in accordance with manufacturer's written instructions and as indicated. Mechanical equipment and applicators shall be capable of accurately and uniformly depositing/spreading the sealcoat mix over the asphalt pavement on a continuous basis. Mechanical equipment and agitators shall be capable of periodically, or continually, agitating the sealcoat mix, as recommended by the manufacturer, and as required to ensure proper suspension and uniformity of mix throughout application.
 - 1. Hand tools shall be used where space limitations prevent use of mechanical equipment or where neatly dressed detail work is required (e.g., along curbs). Care shall be taken to ensure areas of hand tool work are visually comparable to adjacent sealcoat applied by mechanical equipment.
 - 2. Each coat of sealcoat mix shall be applied at minimum rate of 0.12 gallons / sq. yard.
 - 3. Two coats of sealcoat shall be applied to all asphalt pavement areas at application rates indicated and as recommended by manufacturer for the Project and anticipated amount of traffic.
 - 4. Three coats of sealcoat shall be applied where indicated, as recommended by manufacturer, and/or as requested by Architect or Board Authorized Representative in areas where high traffic volumes are anticipated.
 - 5. Allow initial and intermediate coat (when required) to thoroughly dry (tack free and resistant to scuffing) prior to application of subsequent coat of sealcoat.
 - 6. Sealcoat shall be applied uniformly, free of holidays and pinholes.

3.05 FIELD QUALITY CONTROL

- A. Engage a technical site representative of the sealcoat manufacturer to inspect substrate conditions; surface preparation; and application of asphalt sealcoat materials.
 - 1. Technical site representative shall measure thickness with pin tester or other suitable device at least once for every 5,000 sq. ft. and include measurements in written report.

- B. Remove and replace or install additional sealcoat materials, as recommended by manufacturer's technical site representative, where test results or measurements indicate that it does not comply with specified requirements.

3.06 PROTECTION

- A. Prohibit pedestrian and vehicular traffic from seal coated asphalt pavement for not less than 48 hours after sealcoat application is completed.
- B. Before opening seal coated asphalt pavement areas to traffic, examine all areas over which sealcoat materials were applied, with Installer, Architect/Engineer of Record, Board's Representative, and manufacturer's technical field representative present, to verify that sealcoat materials are thoroughly dry (tack free and resistant to scuffing) and free from tracking to adjacent areas.
- C. Protect pavement markings from damage and wear during remainder of construction period.

3.07 CLEANING

- A. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction to the satisfaction of the Architect/Engineer of Record and Board's Representative.

END OF SECTION 32 12 36

SECTION 32 13 13 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Work under this Section is subject to the requirements of the Contract Documents.
- B. Furnish and install all Concrete Pavement work as shown on the Drawings, and as specified herein, including but not necessarily limited to the following:
 - 1. Concrete pavement, sidewalks, driveways and curbs.
 - 2. Curing and sealing concrete.
 - 3. Expansion joints.
- A. Related Requirements:
 - 1. Section 31 20 00 Earth Moving
 - 2. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications". Except as modified herein, the work shall conform to the applicable portions of the Standard Specifications, Sections 423 and 424.

1.2 SUBMITTALS

- A. Submit the following
 - 1. Samples and/or Product Data
 - a. Product Data
 - b. Samples
 - 1) Curing material, 1 pint, or 12" x 12" sheet.
 - 2) Joint filler, 12" length of each type.
 - 3) Concrete Mix Design.
 - 2. Test Reports
 - a. Submit test reports necessary to show compliance with the Contract Documents.
 - 3. Manufacturer's Certification
 - a. Submit certification that products meet or exceed the specified requirements.
 - b. Previous acceptance of mix design in the last 6 months by IDOT or City of Chicago for similar applications.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
- C. Regional Materials: Concrete shall be manufactured within 500 miles of Project site from aggregates and cementitious materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

1.3 QUALITY ASSURANCE

A. Concrete Quality:

1. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
2. ACI Publications: Comply with ACI 301 unless otherwise indicated.
3. The Owner's Testing Agency will be completing all concrete testing, meeting the requirements of ASTM C1077, to design the mix of concrete required in accordance with the Specifications and Drawings. Mix designs prepared by Concrete Suppliers must be tested and verified for compliance with the Specifications by the independent QC testing laboratory.
4. No concrete must be placed until mix designs and 7 and 28 day test results are submitted by the Contractor and accepted by the Owner.
5. If at anytime during construction the concrete resulting from the approved mix design proves to be unsatisfactory for any reason, such as lack of workability, of insufficient strength, the Contractor must immediately notify the QC testing laboratory and the Owner. The QC laboratory must verify the deficiency with additional testing and modify the design, subject to the Owner's approval, until a satisfactory concrete is obtained.
6. The design strength of the concrete must be 4000 psi at 28 days.
7. Solar Reflectance Index: Not less than 29.
8. When an approved water reducing admixture is used in accordance with manufacturer's recommendations, cement requirements may be reduced. Mix designs must indicate use of admixtures.
9. Slump for Portland Cement Concrete (PCC) pavement must be $\frac{3}{4}$ inch to 1-1/2 inches; except that a slump above 1-1/2" may be used, up to a maximum of 3 inches, provided that the mixture's water/cement ratio does not exceed 0.45. Concrete mixes containing plasticizers must have a maximum slump of 8".
10. All concrete exposed to weather or in contact with earth or backfill must be air-entrained. Air-entrained concrete must be made with an air-entraining admixture. Air content must be within limits of 5 to 8 percent, net at time of placement. Air content must be determined in accordance with ASTM C 231.
11. Minimum cement content for PCC pavement must be 535 pounds per cu. yd. of central mixed concrete. Fine aggregate will not be less than $\frac{1}{3}$, not more than $\frac{1}{2}$ of total aggregate.
12. The temperature of the mixed concrete must not be less than 50 degrees F and not more than 90 degrees F at the time of placement. Temperature must be determined in accordance with ASTM C 1064.

B. Perform Work in accordance with the latest edition, of the appropriate divisions, of the following:

1. ACI 311.1R "ACI Manual of Concrete Inspection".
2. ACI 304R "Guide for Measuring, Mixing, Transporting and Placing Concrete", except minimum cement content must be herein specified.
3. CSI "Manual of Standard Practice"
4. ASTM C 94 "Specifications for Ready Mixed Concrete".
5. ACI 305R "Hot Weather Concreting".

6. ACI 306R "Cold Weather Concreting".
7. ACI 308R "Guide to Curing Concrete".
8. ACI 309R "Guide to Consolidation of Concrete".
9. ACI 347 "Guide to Formwork for Concrete".
10. "Standard Specifications for Road and Bridge Construction" prepared by the Illinois Department of Transportation latest edition is a separate book. The "Standard Specifications for Road and Bridge Construction" is referred to in the following articles as the "Standard Specifications" and except as may be otherwise stated, the work to be done under this Section must conform to the requirements of said "Standard Specifications". Contractor's field office and laboratory is not a requirement.
 - a. Unless otherwise noted on Drawings or specified, the applicable articles of the following Sections of the "Standard Specifications" must govern:
 - b. Sections 420, 423 and 424.

(Note: Articles of the SSRBC covering method of measurement and basis of payment are not applicable.)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement - ASTM C 150, Type I cement

B. Fly Ash – ASTM C 618

- C. Aggregate for Normal Weight Concrete - All fine and coarse aggregate must conform to IDOT SSRBC Articles 1003.02 and 1004.02, respectively.
 1. Fine Aggregates - Natural hard clean sand.
 2. Coarse Aggregates - Crushed stone or gravel.
- D. Water - Clean, fresh, potable.
- E. Fiber Reinforcement – Synthetic Macro Fibers at 4 lbs/cy.
- F. Admixtures - Concrete admixtures must comply with ASTM C 494 (Water reducing) or ASTM C 260 (Air Entraining), produced by recognized manufacturers subject to Commissioner's approval.
 1. Air Entraining Admixture - ASTM C 260, "Air Mix" (The Euclid Chemical Company); "MB-VR" (Master Builders); "Darex" (W.R. Grace & Co.); "Sika AER" (Sika Chemical Company); or approved equal. Add only to normal Portland cement concrete to meet requirements specified for air content.
 2. Water Reducing Admixture - ASTM C 494, Type A, and not containing any; chloride ions added during manufacture, "Eucon WR-75" (The Euclid Chemical Company); "Pozzolith" 122N (Master Builders); "WRDA with Hycol" (W.R. Grace & Co.); "Plastocrete" (Sika Chemical Company)-, or approved equal.
 3. Water Reducing, Retarding Admixture - ASTM C 494, Type D. When high temperatures, placing or humidity conditions dictate, "Eucon Retarder-75" (The Euclid Chemical Company); "Pozzolith 100-XR" (Master Builders); "Daratard HC" (W.R. Grace & Co.); "Plastiment" (Sika Chemical Company); or approved equal.

4. Plasticizing Admixture - "Pozzolith-N" (Master Builders)- "WRDA" (W.R. Grace & Co.)-; "Plastiment" (Sika Chemical Company); or approved equal. When ambient temperature is expected to exceed 80 degrees F during placing and finishing operations, use "Pozzolith - R" (Master Builders); "Daratard" (W.R. Grace & Co.); or approved equal.
5. Calcium chloride must not be used.
- G. Bonding Agent - Epoxy type, 100 per cent solids "Euco Epoxy #452 (dry surface), #463" (dry or damp surface), (The Euclid Chemical Company); "Sikadur Hi-Mod" (dry or damp surface) (Sika Chemical Co.); "Duralbond 102" (dry or damp surface), (Dural International Corp.), or approved equal.
- H. Patching and Surfacing Compound - Epoxy type, 1 00 per cent solids, "Euco Epoxy #456 Mortar (dry surface), #460 (dry or damp surface)", (The Euclid Chemical Company); "Sikadur Lo-Mod Mortar" (dry or damp surface) (Sika Chemical Co.); "Duraltex" (dry or damp surface), (Dural International Corp.), or approved equal.
- I. Surface Retardant - (Exposed Aggregate finish) "Lithochrome - Top Surface Grade" (L.M.Scofield Co.), or approved equal.
- J. Form Material - Provide metal or wood templates and forms conforming to profiles, lines and dimensions as shown, of substantial design and construction to maintain position and shape when concrete is placed. All forms must be subject to the acceptance of the Commissioner.
- K. Form Oil - Suitable for the type of forms used and the conditions of use.
- L. Expansion Joint Filler - ASTM D1751 - "Fiber Expansion Joint" W.R. Meadows, or approved equal. Expansion Joint material must be full depth of joint.
- M. Construction Joints - Between all concrete pours suspended for thirty (30) minutes or more, must be a construction joint as shown and detailed on the Plans.
- N. Curing Materials:
 1. Absorptive Cover - Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with ASSHO M 182, Class 3 or cotton mats complying with ASTM C 440.
 2. Moisture-Retaining Cover - One of the following:
 - a. Waterproof Paper - ASTM C 171, Type 1 or Type 11.
 - b. Polyethylene Sheeting - AASHO M 171.
 - c. Polyethylene-coated burlap.
 3. Liquid Membrane Curing Compound - ASTM C 309, Type 1, resin type, clear, unless otherwise directed, for vertical and horizontal surfaces, "Horn Clear-Seal" (W. R. Grace & Co.); "Acri Seal S" Toch Brothers Division, (Carboline Company); "Kure-N-Seal" (Sonneborn-Contech), or approved equal.

2.2 STEEL REINFORCEMENT

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 60 percent.
- B. Welded Wire Fabric - ASTM A1 85.
- C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.

2.3 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.

2.4 SIDEWALKS

- A. Where direction of drainage is across concrete walks, the walks shall normally be uniformly pitched at 2.0% maximum from high to low sides. If the longitudinal gradient of the walk is in excess of 2%, the cross pitch may be reduced to 1/8 inch per foot. Crowned walks shall be permitted only where the longitudinal gradient is at least 2%, with no cross drainage.
- B. Walks shall have a minimum of 5 inch thickness, reinforced with #6 WWF or epoxy rebars, 2 ft. o.c. and shall have 18 inch rebar at 24 inch centers at expansion joints.
- C. Walks shall be finished with stiff broom finish with hand tooled joints to match the existing adjacent sidewalk.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

- A. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
- B. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 CONCRETE PAVEMENT - SIDEWALKS - CURBS - GUTTERS

- A. Construct all concrete pavements, sidewalks, curbs, etc., indicated on the Drawings, to the lines, grades and Sections indicated. Concrete must be proportioned and mixed as specified, strengths as scheduled. Air entraining must be incorporated in the mix by adding an approved admixtures air content of concrete must be within limits of 5% to 8% net at time of placement, in accordance with ASTM C 231.
- B. Unless otherwise indicated or noted on Drawings, lay out pavements into Sections not exceeding 40 feet in length, separated by expansion joints extending full depth of slab. Unless otherwise shown, expansion filler must be 3/4 inch thick, of material as specified.
- C. Unless otherwise indicated or noted on Drawings, expansion joints in curbs must be spaced not more than 40 feet on centers. Unless otherwise shown, joints must be 3/4 inch thick.
- D. Pitch work as indicated on the Drawings for drainage, approximately 1/8 inch per foot, or as required between the new work and existing work to remain, to assure an even transition is made. Level off slabs with strike-off rod and finish to true and even surface with floats and trowel, leaving a smooth surface. After the water sheen has disappeared, the surface must be given a final finish by brushing with a brush drawn across the sidewalk at right angles to the edges of the walk, with adjacent strokes slightly overlapping, producing a uniform, slightly roughened surface with parallel brush strokes. Wheel chair ramps must be similarly finished, except for heavier brooming transverse to slope of ramps.

- E. The surface must be divided by grooves saw cut at right angles to the center line of the pavement or sidewalk. These grooves must be ½ inch deep and not less than _ inch and not more than 1/4 inch in width. Unless otherwise noted on Drawings, spacing of grooves between expansion joints is not to exceed 5'-0" centers.
- F. Forms for concrete curbs and combination concrete curbs and gutters must be removed within 24 hours after the concrete has been placed. Minor defects must be filled with mortar composed of one part Portland cement and two parts of fine aggregate. The exposed surfaces must be finished smooth and given a light brush finish, while the concrete is still green. The edges must be rounded with approved finishing tools having the radii shown on the Drawings.
- G. After the concrete has set sufficiently, the spaces in back of the curb or combination curb and gutter must be backfilled to the required elevation with approved material which must be compacted until firm and solid and neatly grade.
- H. Traffic, loading or backfilling must not be allowed on concrete surfaces for 7 days after the concrete has been placed or until 75% of design strength is achieved. If the Contractor seeks permission from the Commissioner to place traffic, loads, or to backfill before 7 days, the Contractor QC and his laboratory must make and break additional cylinders for this purpose in the Contractor's approved laboratory, subject to verification by the Commissioner.
- I. EDGE FORMS AND SCREED CONSTRUCTION
- J. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- K. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.4 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving:
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

- A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.
- B. Comply with ACI 301 requirements for measuring, mixing, transporting, placing, and consolidating concrete.
- C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- D. Screed paving surface with a straightedge and strike off.
- E. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.6 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
 - 1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
 - 2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
 - 3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.7 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply

according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these.

3.8 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 and as follows:
 - 1. Elevation: 3/4 inch.
 - 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 - 3. Surface: Gap below 10-foot-long, unlevelled straightedge not to exceed 1/2 inch.
 - 4. Joint Spacing: 3 inches.
 - 5. Contraction Joint Depth: Plus 1/4 inch, no minus.
 - 6. Joint Width: Plus 1/8 inch, no minus.

3.9 PAVEMENT MARKING

- A. See Section 32 25 80 "PAVEMENT MARKINGS"

3.10 REPAIRS AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

SECTION 32 17 23.13 - PAINTED PAVEMENT MARKINGS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Parking lot markings, including parking bays, crosswalks, arrows, handicapped symbols, and curb markings.
- B. "No Parking" curb painting.

1.02 REFERENCE STANDARDS

- A. FS TT-P-1952 - Paint, Traffic Black, and Airfield Marking, Waterborne; Rev. E, 2007.
- B. FHWA MUTCD - Manual on Uniform Traffic Control Devices for Streets and Highways; U.S. Department of Transportation, Federal Highway Administration; Current Edition.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings: Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.05 FIELD CONDITIONS

- A. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Line and Zone Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.

- B. Colors: As indicated below. For items not indicated below, provide color(s) as indicated on the Drawings or, if not indicated, as required by the Architect/Engineer of Record.
 - 1. Standard Parking Stalls: White.
 - 2. Accessible Parking Stalls and Access Aisles: Yellow.
 - 3. International Symbol of Accessibility: Blue field with international symbol of accessibility either yellow or white.
 - 4. Stop Lines and Other Traffic Symbols: White.
- C. Paint For Obliterating Existing Markings: FS TT-P-1952; black for bituminous pavements, gray for Portland cement pavements.
- D. Temporary Marking Tape: Preformed, reflective, pressure sensitive adhesive tape in color(s) required; Contractor is responsible for selection of material of sufficient durability as to perform satisfactorily during period for which its use is required.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared and cured.
- B. Proceed only after unsatisfactory conditions have been corrected. Commencement of work in this section will be an indication of the acceptance of sub-grade and the Contractor will be held responsible for the satisfactory execution and results of the finished work.

3.02 PREPARATION

- A. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- B. Clean surfaces thoroughly prior to installation.
 - 1. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods.
- C. Where oil or grease are present, scrub affected areas with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application; after cleaning, seal oil-soaked areas with cut shellac to prevent bleeding through the new paint.
- D. Establish survey control points to determine locations and dimensions of markings; provide templates to control paint application by type and color at necessary intervals.
- E. Do not apply pavement-marking paint until layout of striping, directional arrows and other special designations, colors, and placement as indicated on Drawings have been verified with Architect/Engineer of Record.

3.03 INSTALLATION

- A. Begin pavement marking as soon as practicable after surface has been cleaned and dried.

- B. Do not apply paint if temperature of surface to be painted or the atmosphere is less than 50 degrees F or more than 95 degrees F.
- C. Apply in accordance with manufacturer's instructions using an experienced technician that is thoroughly familiar with equipment, materials, and marking layouts.
- D. Comply with FHWA MUTCD manual (<http://mutcd.fhwa.dot.gov>) for details not shown.
- E. Apply markings in locations determined by measurement from survey control points; preserve control points until after markings have been accepted.
- F. Apply uniformly painted markings of color(s), lengths, and widths as indicated on drawings true, sharp edges and ends.
 - 1. Apply paint in one coat only.
 - 2. Wet Film Thickness: 0.016 inch, minimum.
 - 3. Width Tolerance: Plus or minus 1/8 inch.
- G. Parking Lots: Apply parking space lines, entrance, and exit arrows, painted curbs, and other markings indicated on drawings.
 - 1. Mark the International Handicapped Symbol at indicated parking spaces.
 - 2. Hand application by pneumatic spray is acceptable.
- H. Symbols: Use a suitable template that will provide a pavement marking with true, sharp edges and ends, of the design and size indicated.

END OF SECTION 32 17 23.13

SECTION 32 31 19 - DECORATIVE METAL FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

- A. Scope of this Specification includes Decorative Metal Fences and Gates Basis of Design Cambridge Architectural Fence System manufactured by BASTEEL Perimeter Systems.
 - 1. Consult Manufacturer for further information. BASTEEL Perimeter Systems, 1400 Magnolia Avenue, Frankfort, Indiana 46041, 1-866-369-8335, see <http://www.basteel.com/>
- B. NOTE: BASTEEL also designs and manufactures matching gate systems of similar quality and design attributes, including Swing Gates, Cantilever Gates and Pedestrian Access Gates.

1.2 WORK INCLUDED

- A. Contractor shall provide labor, materials and appurtenances necessary for installation of Steel Architectural Fence System defined herein.

1.3 RELATED WORK

- A. Section 03 30 00 - Cast-In-Place Concrete: Concrete anchorage for posts.
- B. Section 31 00 00 – Site Clearing

1.4 SYSTEM DESCRIPTION

- A. Basis of Design: Manufacturer shall supply a steel decorative architectural fence system of BASTEEL Perimeter Systems Cambridge Architectural Fence System design.

1.5 QUALITY ASSURANCE

- A. Contractor shall provide laborers and supervisors who are thoroughly familiar with type of construction involved and materials and techniques specified. Contractor shall report in writing to Architect prevailing conditions that may adversely affect satisfactory execution of Work.
 - 1. Do not proceed with Work until unsatisfactory conditions have been corrected.
- B. Additional qualifications:
 - 1. Manufacturer: Company specializing in manufacturing Products specified with minimum ten (10) years documented experience.
 - 2. Installer: Company specializing in performing Work of this Section shall have sufficient documented experience in installation of similar Products.

1.6 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM A500/A500M-13: Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
 - 2. ASTM A653/A653A: Standard Specification for Steel Sheet, Zinc-Coated by the Hot-Dip Process.
 - 3. ASTM D2244: Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.

4. ASTM D4214: Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films.
 5. ASTM F1043: Specification for Strength and Protective Coatings for Metal Industrial Fence Framework.
- B. American Architectural Manufacturers Association (AAMA).
1. AAMA 621: Voluntary Specifications for High Performance Organic Coatings on Coil Coated Architectural Hot Dipped Galvanized (HDG) & Zinc-Aluminum Coated Steel Substrates.
- C. American National Standards Institute (ANSI).
1. ANSI B1.13M: Metric Screw Threads: M Profile.

1.7 SUBMITTALS

- A. Manufacturer submittal package shall be submitted in accordance with Section 03 3300 prior to installation.
- B. Manufacturer shall utilize available architectural drawings, customer conceptual drawings, available field measurements and other graphic and verbal information initially provided by Architect to develop proposed project drawings for subsequent review and approval.
- C. Requirements for Submittals:
1. Identify Product Data from Manufacturer regarding gates, posts, accessories, fittings and hardware. Identify applicable certifications including, but not limited to following:
 - a. Made in U.S.A., Buy American Act or otherwise, as required.
 2. Specify applicable requirements related to intended use, such as but not limited to the need for licensed professional engineering (PE) certification.
 3. Provide submittal drawings depicting layout of fence location with field dimensions, location of gates and opening sizes, elevation of fences and gates, details of attachments and footing details, as required.

NOTE: Specific footing requirements may vary due to soil conditions, frost line and other local conditions. Consult with local jurisdictional authority regarding site requirements and local conditions.

4. Verify by field measurements that actual field dimensions and layout shown on submittal drawings accurately reflect customer installation requirements, property survey lines and existing structures.
5. Submit quality assurance information including documentation of installation contractor experience confirming compliance with specified qualification requirements.
6. Manufacturer material certification shall conform to current ASTM or other applicable specifications and shall be made available upon request.

1.8 PRODUCT HANDLING AND STORAGE

- A. Upon delivery, Contractor shall confirm materials were delivered undamaged and items necessary for installation are present on site. Contractor shall report discrepancies to Manufacturer at time they are identified, prior to beginning installation work.
- B. Requirements for Handling and Storage:
1. Prior to and during installation process protect finished metal surfaces with wrapping or strippable coating. Do not use adhesive papers or sprayed coatings that may bond to metal when exposed to sunlight or weather.
 2. Materials shall be securely stored to protect against accidental damage, vandalism and theft in a manner that provides proper ventilation, drainage and protection from anticipated weather conditions.
 3. Product shall be handled in a manner to preserve integrity of finish coating as well as form and function of each fence component.

4. NOTE: Failure to comply with requirements B.1, B.2 or B.3 above shall void Manufacturer Product Warranty.

1.9 PRODUCT WARRANTY

- A. Structural components (i.e. posts, rails, infill pickets) shall be warranted for fifteen (15) years within specified limitations as described within Manufacturer Master Warranty Statement.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. The Basis of Design are products manufactured by:
1. BASTEEL Perimeter Systems, 1-866-369-8335; see <http://www.basteel.com/>
 2. BASTEEL product substitutions are permitted.
 3. Product Substitutions by other manufacturer shall be submitted to Architect in accordance with substitution requirements as set forth in general provisions of Project Manual.

2.2 MATERIALS

- A. Infill pickets 5 inches in width shall be liquid color-coated and then roll formed from minimum 0.017-inch-thick full-hard 80,000 psi minimum yield strength steel in accordance with ASTM A653:
1. Protective coatings shall consist of a hot dip galvanized zinc G-90 under coat; then a two-coat, thermocured paint system consisting of a primer bottom coat and a fluoropolymer top coat. Fluoropolymer top coat shall contain not less than 70 percent polyvinylidene difluoride by weight (e.g. Kynar 500® PVDF resin-based coating) complying with physical properties and coating performance requirements of AAMA 621.
 2. Top coat protection shall meet minimum performance requirements of South Florida outdoor exposure of 45° with a color retention of less than five (5) units color change per ASTM D2244 and a chalk resistance rating of no less than eight (8) per ASTM D4214.
- B. Roll formed C-channel rails and brackets shall be 14 gage ASTM A653 high strength 50,000 minimum psi yield strength steel, having additional characteristics defined below.
1. A protective galvanized G-90 under coat shall be applied prior to 3-mil minimum thickness protective finish layer in specified color, consisting of consisting of
 - a. **super-durable polyester powder coat**, or
 - b. **thermocured fluoropolymer powder coat**
- C. Standard square posts shall conform to ASTM A500 and be either:
1. 4"x 4" high strength steel, 50,000 psi minimum yield strength, zinc coated per ASTM F1043 type B, or
 2. 6"x 6" steel, hot dipped galvanized to minimum thickness of 1.8 oz. per square foot, per side.
 3. Posts shall have 3-mils minimum thickness thermo-cured top coat protective finish layer in the specified color consisting of
 - a. Super-durable polyester powder coat, or
 4. NOTE: For certain products, optional round posts are available to match existing fence.
- D. Infill fasteners shall be series 302 stainless steel 6-Lobe pin-in security truss head, full body shouldered conforming to ANSI B1.13M with a minimum pull out tensile strength of 5,500 N. Carriage bolts and nuts for rails and framing shall be stainless steel. Other fasteners shall be corrosion resistant.
- E. Safety Option

1. Shall be manufactured to match infill panels made available for use on fence systems utilizing vertical infill pickets.
- F. Color Selection:
1. Color to match aluminum metal plate wall panel. See specification 07 42 13.16.
 2. Samples to be provided to Owner and Architect for final approval.

2.3 FABRICATION

- A. Pickets, rails, framing, posts and accessories shall be provided as integral components of an engineered fence system as detailed in Manufacturer shop drawings or as otherwise defined by Manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

- A. New installations shall be laid out by contractor in accordance with information provided by Architect. Verify field measurements, surfaces, substrates and conditions are as required and ready to receive Work.

3.2 FENCE INSTALLATION

- A. Contractor shall consult with local jurisdictional authorities regarding specific utility locate requirements. Contractor shall arrange for local underground utility locate service to identify and locate potential below-grade utility hazards such as electric, gas, water, sewer, telecommunications and similar infrastructure prior to commencing clearing, digging, excavating or fence installation work.
- B. Contractor shall install fencing in accordance with Manufacturer Installation Instructions and approved shop drawings. Fence posts shall be located and spaced in accordance with Manufacturer drawings. Posts shall be set in suitable concrete footers designed and constructed for structural integrity in specific application.
1. Setting of fence posts by other methods (e.g. base plate mounting, grouted core-drilled footers) is permissible only as determined by Architect.
 2. Should contractor elect to substitute foundation design, contractor shall make sure design and construction of alternate foundation design will be sufficient for intended application.
- C. Fence installation may require limited cutting or drilling to accommodate slight variations in field measurements and normal construction tolerances. Contractor shall take reasonable precautions to make sure exposed metal surfaces are properly sealed from environment, as described below:
1. Carefully inspect fence and metal components during installation.
 2. Remove metal shavings from drilling or cutting of posts or metal fence components.
 3. Where drilling or cutting was determined to be necessary, clean metal surfaces and apply two (2) coats of zinc-rich metal primer to thoroughly cover each cut edge or hole drilled during installation processes. Allow each coat to dry thoroughly.
 4. Apply two (2) thin coats of Manufacturer-supplied custom touch-up paint to such locations. Allow each coat to dry thoroughly.
 5. Inspect work and verify each drilled or cut metal surface was properly treated, as described above.
 6. NOTE: Failure to properly clean, prime and finish paint exposed surfaces as described in steps C.1 – C.5 above shall void Manufacturer Warranty.

3.3 FIELD QUALITY CONTROL

- A. Contractor shall perform contractor quality control inspections and document findings upon completion of installation Work.
 - 1. Inspect fence installation, post spacing, fence location dimensions and finishes.
 - 2. Document preparatory, initial and follow-up inspection in Contractor's Test and Inspection Reports.
 - 3. Contractor Test and Inspection Reports shall be available to Architect and Manufacturer upon request.
- B. Contractor shall correct deficiencies in Product and Installation found to be out of compliance with Contract Documents.

3.4 GATES

- A. For projects that include gates, refer to Manufacturer Installation Instructions and Specifications.

3.5 CLEANING

- A. Contractor shall clean jobsite of excess fence materials as well as remaining packing and shipping materials. Post hole excavation material shall be scattered uniformly away from posts unless otherwise specified within Contract Documents.

END OF SECTION 32 31 19

SECTION 32 35 00 – ADA TILES

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. Work under this item shall consist of installing cast iron detectable warning tiles on ADA curb ramps as shown on the plans.
- B. Related Sections:
 - 1. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. “Standard Specifications”. Except as modified herein, the work shall conform to the applicable portions of the Standard Specifications, Section Sections 424”. Articles of the Standard Specifications covering “Method of Measurement” and “Basis of Payment” are not applicable.

1.3 SUBMITTALS

- A. Contractor shall submit to the Engineer product data and manufacturer’s written certifications that the material complies with these specifications.

PART 2 - PRODUCTS

2.1 CAST IRON ADA TILES

- A. The cast iron detectable warning tiles shall be of uniform quality, free from surface defects and shall be provided with an untreated, natural surface finish.

PART 3 – EXECUTION

- 3.1 The detectable warning system shall be installed in fresh concrete. The equipment and installation procedures shall be according to the Manufacturer’s specifications.
- 3.2 The contractor shall install the detectable warning system flush with adjacent concrete, and resulting in a snug fit between tiles to limit water infiltration around the perimeter of the system and between tiles

END OF SECTION 32 35 00

SECTION 32 91 00 - TEMPORARY SOIL EROSION CONTROL

PART 1 GENERAL

1.1 SUMMARY

- A. This item consists of temporary control measures as shown on the Plans or as ordered by the Owner during the life of a Contract to control water pollution, soil erosion, and sediment control through the use of aggregate berms, earth berms, temporary ditches, ditch and watercourse checks, sediment traps, sediment logs, erosion control blankets, stone, temporary seeding, inlet and pipe protection, and other erosion control devices or methods.
- B. This special provision will be used in conjunction with the plan documents and the Storm Water Pollution Prevention Plan (SWPPP).
- C. The Contractor must control soil erosion in accordance with the provisions of NPDES permit issued by the Illinois Environmental Protection Agency (IEPA) for stormwater discharges from construction site activities.
- D. The Contractor must meet the Specifications of the Illinois Urban Manual (latest edition, published by IEPA and Illinois Natural Resources Conservation Service), as modified in the Contract Drawings and Specifications.
- E. The Contractor must coordinate temporary erosion control measures with the permanent erosion control measures to the extent practical to assure economical, effective, and continuous erosion control throughout the construction period.
- F. Temporary erosion control is not limited to areas within the construction limits; construction operations at sites such as borrow pits, equipment and material storage sites, waste areas, temporary stock piles, temporary plant sites, and others are also subject to erosion control requirements.
- G. The best way to prevent sediment from entering storm sewer systems and waterways is to stabilize the disturbed areas of a site as quickly as possible, preventing erosion and stopping sediment transport at its source.
- H. Prior to commencing land disturbing activities other than those indicated on the Plans (including but not limited to additional phases of the development and off-site borrow, waste, asphalt and/or concrete batch plant areas) a supplemental erosion and sediment control plan must be submitted to the Owner for review and approval.
- I. Related Requirements:
 - 1. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications". This work shall be performed in accordance with the applicable portions of the Standard Specifications, Sections 250 and 281, as well as Articles 1080.02. Articles of the Standard Specifications covering "Method of Measurement" and "Basis of Payment" are not applicable.
 - 2. Illinois Urban Manual, Latest Edition.

1.2 DEFINITIONS

- A. Channels: All ditches and watercourses will be considered “channels.”

1.3 SUBMITTALS

Contractor to submit Product Data – catalogs, brochures, and performance and test data to support conformance with the Specifications for the materials to include but not limited to:

- A. Temporary Seed – Signed statement by Vendor certifying that each lot of seed has been tested by a recognized laboratory for seed testing, within 6 months of delivery. Statement must include: name and address of laboratory, date of test, lot numbers for each kind of seed, results of the tests as to seed name, percentages of purity, and of germination, and in case of mixture, the proportion of each kind of seed.
- B. Fertilizer
- C. Silt Fence and Stakes
- D. Sediment Containment Filter Bag
- E. Inlet Protection
- F. Geotextile Fabric
- G. Concrete Washout Facility – 30 mil polyethylene liner
- H. Aggregates – Gradation test for each size of aggregate by a certified testing laboratory.

PART 2 PRODUCTS

2.1 SEEDING, TEMPORARY

- A. Temporary Protection by Vegetation.

- 1. Seed:

- a. For disturbed areas that will not be in the active work area between 14 days and 365 days, seed must be applied at the following rates:
 - 1) Seed with 150 lbs. per acre of wheat or cereal rye, or
 - 2) Seed with 100 lbs. per acre of spring oats.

2.2 FERTILIZER

- A. Fertilizer must meet the Standard Specifications of Section 250.

2.3 SILT FENCE

- A. Materials for silt fence must be in accordance with the Standard Specifications Article 1080.02.

2.4 COARSE AGGREGATE AND RIPRAP

- A. Coarse Aggregate and Riprap material (for Rock Check Dam, Aggregate Berm, Riprap, Inlet and Pipe Protection, Construction Entrances, or other erosion control functions) used for erosion control must meet the requirements of the Standard Specifications. Coarse Aggregate and Riprap for erosion control must be crushed/broken recycled concrete or crushed stone. Coarse Aggregate must consist of CA-1, CA-2, CA-3 or CA-4 as indicated on the Drawings; and Riprap must consist of Gradation No. RR3 or RR 4; and geotextile fabric must meet the requirements of the Standard Specifications Article 1080.02.

2.5 SEDIMENT CONTAINMENT FILTER BAG

- A. Sediment Control Filter Bags must be ACF Environmental ERO-TEX dewatering filter bag, US Fabrics filter bag, or JMD Enviro-Protection filter bag as approved by the Owner, of the size required to adequately filter pumped water per the manufacturers' specifications.

2.6 INLET PROTECTION

- A. Materials for Above Ground Inlet protection must be per manufacturer's specification, and as approved by the Owner. Acceptable products for above ground inlet protection include the following:
 - 1. Dandy Bag, Curb Bag, and Dandy Pop by Dandy Products
 - 2. Sediguard Inlet Protection Device by Earth Support Systems
 - 3. Storm Drain Inlet Frame and Filter Assembly by Silt Saver Sediment Control Products
- B. Materials for Below Ground Inlet protection must be per manufacturer's specification, and as approved by the Owner. Acceptable products for below ground inlet protection include the following:
 - 1. Catch-All Inlet Protector by Mar-Mac Manufacturing Co., Inc.
 - 2. Dandy Sack and Dandy Curb Sack by Dandy Product
 - 3. SedCatch Sediment Basket by SedCatch Environmental Products
- C. Inlet protection is only to be used as a filter for sheet flow or in conjunction with a sediment containment filter bag. Inlet protection is not to be used as a filter for dewatering directly to the structure.

2.7 SUMP PIT

- A. Materials for Sump Pit must be 2 inch Coarse Aggregate and a filter fabric, with a ¼ to ½ inch hardware cloth wire placed around the standpipe prior to attaching the filter fabric.

2.8 GEOTEXTILE FABRIC

- A. Geotextile fabric material must meet the requirements of the Standard Specifications Article 1080.02.

2.9 TEMPORARY CONCRETE WASHOUT FACILITY

- A. Install a device to control concrete wastes to prevent both on-site and off-site pollution. The device must be installed on any construction site where concrete is used.

- B. Temporary concrete washout facility must be in accordance with Straw Bale Type as shown on plan, or Contractor provided alternate.
- C. Temporary concrete washout facilities must be supplied in sufficient quantity and size to manage all liquid and solid wastes generated by washout operations.
- D. The walls of above grade facilities may be constructed of straw bales, barrier walls, or earthen berms. Straw bales and barrier walls must be butted tightly end-to-end. All types of concrete washout facilities must be lined with a 30-mil polyethylene liner free of holes and tears and must be secured using sandbags, 6" wire staples, or other anchors, as approved by the Owner.

2.10 OTHER

- A. All other materials must meet commercial grade standards and must be approved by the Pace before being incorporated into the Project.

PART 3 EXECUTION

3.1 GENERAL

- A. In the event of conflict between these requirements and pollution control laws, rules, or regulations of other federal, state, or local agencies, the more restrictive laws, rules, or regulations must apply.

3.2 SCHEDULE

- A. Prior to the start of construction, the Contractor must submit schedules (timing for erosion control work to be performed relative to other construction items) for accomplishment of temporary and permanent erosion control work. The Contractor must also submit a proposed method of erosion and dust control on haul roads and borrow pits and a plan for disposal of waste materials. Work must not be started until the erosion control schedules and methods of operation for the applicable construction have been accepted by the Owner and initial erosion control items have been properly installed.

3.3 AUTHORITY OF OWNER

- A. Owner has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, to limit the surface area of erodible earth material exposed by excavation, borrow and fill operations, and to direct the Contractor to provide immediate permanent or temporary pollution control measures to minimize contamination of adjacent streams or other watercourses, lakes, ponds, or other areas of water impoundment.

3.4 STABILIZED CONSTRUCTION ENTRANCE / EXIT

- A. Construction entrance / exit must be used at all points of construction ingress and egress to the public road.
- B. The aggregate for the construction entrance / exit must meet the requirements of Standard Specifications Article 1004.01.
- C. Each construction entrance / exit must meet the following minimum dimensions: thickness of 12 inches, width of 20 feet; but not less than full width of ingress or egress point, and length of 100 feet.

Filter fabric must be installed under aggregate to minimize the migration of the stone into the underlying soil.

3.5 DEWATERING

- A. Sump Pit. Pumping water from open trenches or other areas must be performed in a manner to minimize the turbidity of the pumped water.. The pumping operation must start with the installation of the intake hose into the Sump Pit and then discharge directly into a sediment trap, stabilized ditch, temporary stabilized ditch that leads to a sediment trap, designed treatment channel, sediment containment filter bag, or another Best Management Practice (BMP) that is approved by the Owner.
- B. Sediment Containment Filter Bag. When water cannot be pumped directly to a sediment trap, or site conditions call for use of an additional layer of erosion control, water must be pumped directly into a Sediment Containment Filter Bag. Sediment Containment Filter Bags must be used according to the manufacturer's instructions, as modified by the Contract Drawings and Specifications. Sediment Containment Filter Bag must be placed flat on a stabilized surface as shown in the Drawings.

3.6 TEMPORARY STOCKPILES

- A. Stockpile Sediment and Erosion Control. If a stockpile is to remain in place more than 3 days, perimeter barrier must be installed and "tracking" with machinery (tracking up and down the slope parallel to the direction of the slope, such that the track cleat marks are perpendicular to the direction of the slope in order to prevent the development of erosion rills/gullies) must be provided. If the construction activity temporarily or permanently ceased and construction activity will not occur for a period of 14 days, temporary stabilization must be provided for each stockpile by the 7th day after activity has ceased. If the stockpile is to remain inactive for more than 365 days, the stockpile must be permanently seeded per Contract Specifications. Stockpile sediment and erosion control can include Temporary Seeding, Permanent Seeding, Polymer, Silt Fence, Erosion Control Blanket, or other methods approved by the Owner. Contractor must maintain the installed sediment and erosion control measures for the duration of the Project or until the Contractor's responsibilities for maintenance cease as determined by the Owner.

3.7 SEDIMENT TRAPS and TEMPORARY DITCHES

- A. Sediment Trap: Sediment Traps are relatively effective at trapping medium to coarse-grained particles, and must meet the following Specifications:
 - 1. Depth. Sediment trap must be a minimum of 2 feet measured from the sediment trap bottom to the invert of the stone outlet to provide sediment and detention storage.
 - 2. Shape: Sediment trap must have a length-width ratio of at least 2:1. Side slopes must be no steeper than 2:1 (h:v) and must be stabilized.
 - 3. The surface of the trap must be stabilized with Geotextile Fabric which meets the Illinois Urban Manual material Specification 592. The trap must be maintained and regularly cleaned of sediments to maintain its holding capacity. Any damaged fabric must be replaced or repaired.
 - 4. Outlet: The position of the outlet must be as such to minimize short-circuiting of the water flow path. The crest of the spillway must be at least 1 foot below the top of the embankment. The width of the rock check dam outlet must span the width of the outlet channel. The top of the rock check dam outlet must be constructed so that the center is approximately 6 inches lower than the outer edges. Discharge from the outlet must be to a stabilized area.

B. Stone Outlet Structure for Sediment Trap

1. Riprap (RR-4) for Stone Outlet Structure must meet requirements of the Standard Specifications for Road and Bridge Construction (SSRBC).
2. Geotextile Fabric must meet requirements of the Illinois Urban Manual material Specification 592.
3. Cost of Geotextile Fabric is included in the pay item of stone outlet structure for sediment trap and no additional payment will be made.

C. Temporary Ditch. Temporary Ditches must be constructed as shown on the Drawings or as directed by the Owner to provide drainage paths to sediment traps. These ditches must have side slopes no steeper than 2:1 (h: v). The slopes of the temporary ditch must be stabilized with Temporary Seeding, Erosion Control Blanket, (single, double net or TRM), Geofabric, and/or Riprap as directed by the Owner, before ditches convey flow.

3.8 INLET AND PIPE (CULVERT) PROTECTION

- A. All inlets to storm sewers that will potentially be affected by the Contractor's construction activities must be protected with Inlet and Pipe Protection barriers. Coarse Aggregate for culvert protection, above ground and below ground inlet protection meeting manufacturer's specification and as approved by the Owner must be installed at the direction of the Owner.
- B. Inlet protection must be constructed before upslope land disturbance begins and before the storm drain becomes operational.
- C. The inlet protection barriers must allow for overflow from a severe storm event.

3.9 SILT FENCE

- A. Silt Fence must be installed in accordance with the Illinois Urban Manual where erosion would occur in the form of sheet flow and there is no concentration of water flowing to the barrier. Silt Fence must be placed as close to the contour as possible with the ends extending upslope. The area below the fence if possible, must be undisturbed or stabilized. Fence posts must be a minimum of 48 inches long and with a minimum cross sectional area of 3.0 square inches. The maximum spacing between posts must be 5 feet and driven a minimum of 18 inches into ground. The silt fence must be entrenched to a minimum depth of 6 inches with an additional 6 inches extending along the bottom of the trench in the upslope direction.

3.10 RIPRAP AND COARSE AGGREGATE

- A. Riprap and Coarse Aggregate are specified for use in several erosion control items as shown on the detail Drawings.
- B. Where filter fabric is required on the Drawings, the fabric must conform to the Illinois Urban Manual material Specification 592 Geotextile.
- C. Coarse aggregate and riprap or rock/reclaimed concrete for Culvert Inlet Stone Protection, Rock Check Dams, Temporary Sediment Trap, Stabilized Construction Entrance, Construction Road Stabilization, and Temporary Stream Crossing must be placed in accordance with the IL Urban Manual construction Specification 25 Rockfill, using Method 1 and Class III compaction.

1. Foundations for rockfill must be stripped to remove vegetation and other unsuitable materials. Earth foundation surfaces must be graded to remove surface irregularities and cavities filled with compacted earthfill of approximately the same kind and density as the adjacent foundation material. Rockfill and/or bedding must not be placed until the foundation preparation is completed and the foundation or excavations have been inspected and approved by the Owner.
 2. Reclaimed concrete materials must be free from reinforcing bars.
 3. For Method 1 placement, the rock must be dumped and spread into position in approximately horizontal layers not to exceed 3 feet in thickness. It must be placed in a manner to produce a reasonably homogeneous stable fill that contains no segregated pockets of large or small fragments or large unfilled rock fragments.
 4. Moisture content of the bedding material must be controlled to ensure that bulking of the sand material does not occur.
 5. Class III Compaction of Rockfill and Bedding – No compaction will be required beyond that resulting from the placing and spreading operations.
- D. Riprap for Pipe Outlets and Structural Streambank Stabilization must be placed in accordance with the Illinois Urban Manual construction Specification 61 Rock Riprap.
1. The subgrade surfaces on which the rock riprap, filter, bedding or geotextile is to be placed must be cut or filled and graded to the lines and grades as shown on the Drawings. When fill to subgrade lines is required, it must consist of approved materials and conform to the requirements of the specified class of earthfill. Rock riprap, filter, bedding or geotextile must not be placed until the foundation preparation is completed and the subgrade surfaces have been inspected and approved by the Owner.
 2. Equipment-Placed Rock Riprap

The rock riprap must be placed by equipment on the surfaces and to the depths specified. The rock riprap must be installed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock for riprap must be delivered and placed in a manner that will ensure that the riprap in-place will be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact one to another with the smaller rocks and spalls filling the voids between the larger rocks. Some hand placing may be required to provide a neat and uniform surface. Rock riprap must be placed in a manner to prevent damage to structures. Hand placing will be required or necessary to prevent damage to any new and existing structures.
 3. Hand-Placed Rock Riprap

The rock riprap must be placed by hand on the surfaces and to the depths specified. It must be securely bedded with the larger rocks firmly in contact one to another without bridging. Spacers between the larger rocks must be filled with smaller rocks and spalls. Smaller rocks must not be grouped as a substitute for larger rock. Flat slab rock must be laid on its vertical edge; except where it is laid like paving stone and the thickness of the rock equals the specified depth of the riprap course.

When the Drawings specify filter, bedding or geotextile beneath the rock riprap, the designated material must be placed on the prepared surface as specified. Compaction of filter or bedding aggregate will not be required, but the surface of such material must be finished reasonably smooth and free of mounds, dips, or windrows.

3.11 MULCH AND EROSION CONTROL BLANKET

- A. Mulch must be installed immediately after seeding by conventional method or hydromulching, after seedbed preparation, when dormant seeding is to be provided and when temporary erosion control is to be attained. Mulch must be applied any time soil and site conditions are suitable for spreading and anchoring.
- B. The erosion control blanket (single, double net or TRM) must be installed in accordance with the Manufacturer's specification and requirements. The erosion control blanket must be in firm contact with the soil. It must be anchored per the manufacturer's recommendation with the proper number and spacing of wire staples. The staples must be the proper width and length to meet the Manufacturer's specification. On slopes and in channels the blanket must be unrolled upstream to downstream parallel to the direction of flow. The upstream end and at the top of the slope, each blanket must be anchored in a minimum 6-inch deep anchor trench. The blankets must be laid like shingles, i.e., ends and edges of blanket sections must be overlapped in rows in the direction of flow.
- C. The type of erosion blanket must be based on the flow velocity and shear force in the channel.

3.12 TEMPORARY SEEDING

- A. This work consists of the temporary seeding of unfinished, disturbed areas as designated by the Owner within the construction site.
- B. Except as provided in paragraphs 3.12C and 3.12D below, stabilization measures must be initiated as soon as practical in portions of the site where construction activities have temporarily or permanently ceased.
 - 1. Disturbed areas that will not be in the active work area for 14 to 90 days must be seeded within 24 hours after suspension of work in the area with no fertilizer or seedbed preparation, or, must be seeded within 7 working days after suspension of work in the area with no fertilizer and with rough seedbed preparation.
 - a. During dormant seasons (between June 15 and August 15 and between November 15 and December 31 or until the ground becomes frozen) mulch must be applied.
 - 2. Disturbed areas that will not be in the active work area for 90 to 365 days must be seeded and fertilized within 24 hours after suspension of work in the area with no seedbed preparation, or, must be seeded and fertilized within 7 working days after suspension of work in the area with rough seedbed preparation.
 - a. During dormant seasons (between June 15 and August 15 and between November 15 and December 31 or until the ground becomes frozen) mulch must be applied.
 - 3. Disturbed areas that will not be in the active work area for longer than one year must be seeded and fertilized in accordance with Section T-901 (Seeding) within 7 working days after suspension of work in the area with seedbed preparation.
- C. Where the initiation of stabilization measures by the 7th day after construction activity temporary or permanently cease is precluded by snow cover, stabilization measures must be initiated as soon as practical.
- D. Where construction activity will resume on a portion of the site within 14 days from when activities ceased, (e.g. the total time period that construction activity is temporarily ceased is less than 14 days) then

stabilization measures do not have to be initiated on that portion of site by the 7th day after construction activity temporarily ceased.

- E. Dates: Temporary seeding must occur between March 15 and October 1. If protection is required outside of these dates, mulch must be used.
- F. Seed Bed Preparation: Seedbed preparation must be as described in Section T-901, Seeding. A rough seedbed must be obtained with a minimum of one pass with a disc harrow.
- G. Fertilization of Temporary Vegetation. The Contractor must perform soil tests to determine the amount of fertilizer necessary. The following rates of fertilizer application are the benchmark application rates per acre, but the Contractor must aim to minimize the amount of fertilizer used, while still allowing for the healthy growth of the seed.
 - 1. Nitrogen (N) - 120 pounds of N
 - 2. Phosphorus (P) - 60 pounds of P205
 - 3. Potassium (K) - 60 pounds of K₂O

3.13 MAINTENANCE OF TEMPORARY CONCRETE WASHOUT FACILITY

- A. Perform washout of concrete trucks in designated areas only. Each temporary washout facility must have appropriate signage to inform concrete truck drivers and equipment operators of the proper washout locations. The concrete washout facility must be installed prior to any concrete placement on site.
- B. Each facility must be located in an area protected from possible damage from construction traffic and have stabilized access to prevent tracking onto streets. Washout facilities must be located on level ground a minimum of 50 feet from storm drain inlets and open drain facilities. For smaller sites where the distance criteria may not be practical, washout facilities must be located as far from drainage facilities as possible and additional inspections must be conducted to ensure no illicit discharges occur.
- C. Washout water from low volume facilities must be allowed to evaporate and not be discharged into the environment. Washout water from high volume facilities must be removed with a vacuum truck and taken back to the batch plant.
- D. Solidified concrete waste from washout facilities shall be considered Clean Construction or Demolition Debris (CCDD) as per the Illinois Environmental Protection Act (415 ILCS 5) and must be disposed of in accordance to the Act.
- E. Temporary concrete washout facilities must be maintained to provide adequate holding capacity with a minimum freeboard of 4 inches for above grade facilities and 12 inches for below grade facilities. Existing facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is two-thirds full.
- F. Maintaining temporary concrete washout facilities must include removing and disposing of hardened concrete or slurry and waste in accordance with Federal and State regulations or as directed by the Owner, and returning the facilities to a functional condition.
- G. When temporary concrete washout facilities are no longer required for the Work, the facilities must be removed from the site. Holes, depressions, or other ground disturbances caused by the removal must be

restored to the satisfaction of the Owner. The disturbed area must be seeded and mulched or otherwise stabilized in a manner acceptable to the Owner.

3.14 CONSTRUCTION DETAILS

- A. The Contractor must incorporate all permanent erosion control features into the Project at the earliest practical time as outlined in the accepted schedule.
- B. Temporary erosion and pollution control measures must be used (1) to correct conditions that develop during construction that were not foreseen during the design stage; (2) where needed prior to installing permanent control features; or (3) to temporarily control erosion that develops during normal construction practices, but are not associated with permanent control features on the Project.
- C. Where erosion is likely to be a problem, clearing and grubbing operations should be scheduled and performed so that grading operations and permanent erosion control features can follow immediately thereafter if the Project conditions permit; otherwise, temporary erosion control measures may be required between successive construction stages.
- D. The Owner will limit the area of clearing and grubbing, excavation, borrow, and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding, and other such permanent control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measures must be taken immediately to the extent feasible and justified.
- E. In the event that temporary erosion and pollution control measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled or are ordered by the Owner, such work must be performed by the Contractor at his/her own expense.
- F. The Owner may increase or decrease the area of erodible earth material to be exposed at one time as determined by analysis of Project conditions.
- G. The erosion control features installed by the Contractor must be maintained by the Contractor during the construction period to the satisfaction of the Owner.
- H. Whenever construction equipment must cross watercourses at frequent intervals, temporary structures must be provided.
- I. Pollutants such as fuels, lubricants, bitumen, raw sewage, wash water from concrete mixing operations, and other harmful materials must not be discharged into or near rivers, streams, and impoundments or into natural or manmade channels leading thereto. Contractor must dispose all materials properly at an approved location and according to the local regulations.

3.15 OPERATION AND MAINTENANCE

- A. All installed erosion control features must, at a minimum, be inspected at least once every 7 days and within 24 hours of a storm event that produces 0.5 inches of rain or more during a 24-hour period, in accordance with NPDES permit.

- B. Removal. Unless incorporated into the permanent stormwater management system, all erosion control features must be removed and properly disposed of once final grading and stabilization has been completed, or at the direction of the Owner.
- C. Surplus or waste material. Surplus or waste material resulting from the riprap operations must be disposed of by the Contractor at his own expense.
- D. The Contractor must be solely responsible for the maintenance of all soil erosion devices installed by the Contractor. Maintenance must be completed as soon as possible with consideration to site conditions.
- E. For each specific Erosion and Sediment control measure maintenance and inspection, refer to the Illinois Urban Manual Standard practice.

END OF SECTION 32 91 00

SECTION 33 05 17 - SEWER STRUCTURES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Furnish and install, reconstruct or adjust Manholes and Catch Basins in accordance with these Specifications at the specified landside locations and conforming to the lines, grades, and dimensions shown on the Plans.
- B. Related Work Specified In Other Sections Includes, But is Not Limited to, the Following:
 - 1. Section 01 10 00 - Summary of Work
 - 2. Section 01 33 00 - Submittals
 - 3. Section 03 30 00 - Cast-in-Place Concrete
 - 4. Section 32 12 00 - Asphalt Paving
 - 5. Section 32 13 00 - Concrete Paving
 - 6. Section 33 30 00 - Sanitary and Storm Sewerage
 - 7. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications". This work shall be performed in accordance with the applicable portions of the Standard Specifications, Sections 602 and 604". Articles of the Standard Specifications covering "Method of Measurement" and "Basis of Payment" are not applicable.

1.2 REFERENCES

- A. Chicago Department of Transportation, Regulations for Openings, Construction and Repair in the Public Way, latest edition.
- B. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications".
- C. ACI 318 - Building Code Requirements for Reinforced Concrete
- D. ASTM C478 - Standard Specifications for Precast Reinforced Concrete Manhole Sections.
- E. City of Chicago, Department of water Management, Standard Specification for Water and Sewer Main Construction, Latest Edition
- F. Standard Specification for Water and Sewer Main Construction in Illinois (SSWSMC).

1.3 SUBMITTALS

- A. Submit the following:
 - 1. Shop Drawings
 - 2. Samples and/or Product Data
 - a. Product Data:
 - (1) Catalog cuts of frame and grates for manholes and catch basins.
 - (2) Catalog cuts for pre-cast manholes and catch basins, including accessories.

- b. Test Reports
- a. Submit test reports necessary to show compliance with the Contract Documents.
- c. Manufacturer's Certification
- d. Submit certification that products meet or exceed the specified requirements.

1.4 WARRANTY

- A. The Contractor must repair or replace defective materials and workmanship during the Contract Period and for one (1) year or manufacturer standard if longer from the date of Substantial Completion of the Project.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Delivery, storage and handling must be done in such a manner to prevent damage to the segments.
- B. Precast sections must not be shipped nor subjected to loading until compressive strength has attained 3,000 pounds per square inch (PSI) or five days after fabrication, whichever is longer.
- C. Base, riser, cone and flat top precast sections, frames and covers must be delivered to site when required by approved project schedule.

PART 2 PRODUCTS

2.1 CONCRETE:

- A. Plain and reinforced concrete used in structures, connections of pipes with structures, and the support of structures or frames must conform to the requirements of Section 03 30 00 - Cast-in Place Concrete except that the concrete must have a compressive strength of 4500 psi after 28 days.

2.2 MORTAR:

- A. The mortar must be composed of 1 part of Portland cement and 2 parts of mortar sand by volume. The Portland cement must conform to the requirements of AASHTO M 85. The sand must conform to the requirements of AASHTO M 45. Hydrated lime may be added to the mixture of sand and cement in an amount not to exceed 15% of the weight of cement used. The hydrated lime must meet the requirements of ASTM C 206. The water must be clean and free of deleterious amount of acids, alkalis, or organic material. If the water is of questionable quality, it must be tested in accordance with AASHTO T 26.

2.3 PRECAST CONCRETE PIPE MANHOLE SECTIONS:

- A. Precast concrete pipe manhole sections must conform to the requirements of ASTM C76, Class 11. Adjustment rings must conform to ASTM C 478.

2.4 FRAMES, COVERS, AND GRATES:

- A. Castings for use at landside locations must conform to the requirements for Ductile Iron castings and requirements of ASTM A-536, and must be capable of supporting an H-20 loading. Acceptable manufacturers are Neenah Foundry Company, East Jordan Iron Works, Inc. and Campbell Foundry All castings or structural steel units must conform to the dimensions shown on the Plans and must be designed to support the loadings specified.

- B. All lids must be marked "STORM SEWER", "SANITARY", or "WATER", whichever is appropriate, in 2 inch raised capital letters.

- C. Prior to shipment, all castings must be thoroughly cleaned. After fabrication, structure steel units must be galvanized to meet the requirements of AASHTO M 111.

2.5 STEPS:

- A. The steps or ladder bars must be gray aluminum. The steps must be the size, length, and shape shown on the Plans.

2.6 GRADE RINGS:

- A. Pre-cast concrete grade rings must meet the requirements of ASTM C478.

2.7 BEDDING MATERIAL:

- A. Bedding under bases or foundations must be fine aggregate trench backfill in accordance with Section 32 11 16 – Subbase Courses.

PART 3 EXECUTION

3.1 GENERAL:

- A. The Contractor must do all excavation of structures and structures footings to the lines and grades or elevations shown on the Contract Drawings. The excavation must be of sufficient size to permit the placing of the full width and length of the structure or structure footing shown.
- B. Boulders, logs, or any other objectionable material encountered in excavation must be removed. All rock or other hard foundation material must be cleaned of all loose material and cut to a firm surface. Rock or other unsuitable material must be removed and replaced with fine aggregate trench backfill. The foundation for the structure must be undisturbed ground with a minimum of 6 inches of fine aggregate trench backfill.
- C. The Contractor must furnish and install all temporary earth retention necessary to implement and protect the excavation and the structures as required for safety or conformance to governing laws. The temporary earth retention system will be included in this work.
- D. Unless otherwise provided, temporary earth retention system involved in the construction of this item must be removed by the Contractor after the completion of the structure. Removal must be effected in a manner which will not disturb or mar finished masonry.
- E. After each excavation is completed, the Contractor must notify the Commissioner to that effect; and concrete or reinforcing steel must be placed after the Commissioner has approved the depth of the excavation and the character of the foundation material. All excavation must be included in the individual drainage structure.
- F. The Contractor must verify the required minimum bearing beneath the concrete structure. Contractor QC to verify bearing to 3 feet minimum or to depth as directed by the Commissioner. The cost of verifying the required bearing will be considered included and incidental to the price of the structure.

- G. Where suitable bearing conditions is not encountered at subgrade indicated for footings, foundations and manholes/catch basins, the Commissioner may direct additional excavation and backfill with stabilization stone as necessary.

3.2 CONCRETE STRUCTURES:

- A. Concrete structures must be built on prepared foundations, conforming to the dimensions and form indicated on the Contract Drawings. The construction must conform to the requirements specified in Section 03300 - Cast-In-Place Concrete. Any reinforcement required must be placed as indicated on the Contract Drawings and must be approved by the Commissioner before the concrete is poured.
- B. All invert channels must be constructed and shaped accurately so as to be smooth, uniform, and cause minimum resistance to flowing water. The interior bottom must be sloped downward toward the outlet.

3.3 PRE-CAST REINFORCED CONCRETE STRUCTURES:

- A. Pre-cast reinforced concrete structures must be installed on prepared or previously constructed slab foundations and must conform to the dimensions and locations shown on the Contract Drawings. All pre-cast reinforced concrete sections necessary to build a complete structure must be furnished. The different sections must fit together readily, and all jointing and connections must be cemented with mortar. The top of the upper precast concrete member must be suitably formed and dimensioned to receive the metal frame and cover or grate, or other cap, as required. Provision must be made for any connections for lateral pipe, including drops and leads that may be precast in the structure. The flow lines must be smooth, uniform, and cause minimum resistance to flow. The steps which are embedded or built into the side walls must be aligned and placed at vertical intervals at 16 inches on center or as indicated in the Plans.

3.4 INLET AND OUTLET PIPES:

- A. Inlet and outlet pipes must extend through the walls of the structure for a sufficient distance beyond the outside surface to allow for connection but must be cut off flush with the wall on the inside surface, unless otherwise directed.

3.5 PLACEMENT AND TREATMENT OF CASTINGS, FRAMES, AND FITTINGS:

- A. All castings, frames, and fittings must be placed in the positions indicated on the Plans or as directed by the Commissioner, and must be set true to line and to correct elevation, all anchors or bolts must be in place and position before the concrete or mortar is placed. The unit will not be disturbed until the mortar or concrete has set.
- B. When frames or fittings are to be placed upon previously constructed masonry, the bearing surface or masonry must be brought true to line and grade and must present an even bearing surface in order that the entire face or back of the unit must come in contact with the masonry. The unit must be set in mortar beds and anchored to the masonry as indicated on the Contract Drawings or as directed and approved by the Commissioner. All units must be set firm and secure.
- C. After the frames or fittings have been set in final position and the concrete or mortar has been allowed to harden for 7 days, then the grates or covers must be placed and fastened down.

- D. When pre-cast concrete grade rings are used to reset frames to a new elevation, no more than four rings may be used. Total adjustment must be no more than 12 inches.

3.6 INSTALLATION OF STEPS:

- A. When steps are required with pre-cast concrete structures, they must be cast into the sides of the concrete structures at the time the sections of the structure are manufactured or the steps may be set in place after the structure is erected by drilling holes in the concrete and cementing the steps in place.

3.7 ADJUSTMENT OF STRUCTURES

- A. Structures requiring vertical adjustment must be brought to proposed grade by either adding or removing concrete adjustment rings as required. Mortar must be placed between each layer of adjusting rings and must be composed of one-part masonry cement to three parts sand, by volume. Frames must be set firm, secure, true to line and to the correct elevations. This adjustment will include centering and adjusting the grade of existing frame and sealing the frame on the existing structures. Frames and Grade adjusting rings will be installed with mastic to prevent seepage of water into the manhole. Grade shall be established as a minimum of 1% from the lowest point on the existing adjacent pavement.
- B. When precast concrete adjusting rings are used to adjust frames to proposed or new elevation, no more than four rings may be used. Total adjustment must be no more than 12 inches.
- C. Adjustments in excess of one foot must have new precast riser sections installed. All required riser sections must be considered included in the adjustment of the structures.

3.8 BACKFILLING:

- A. After a structure has been completed, backfill in accordance with the requirements of the detailed Drawings and Section P-157 - Trench Backfill.
- B. Backfilling must not be placed against any structure until permission is given by the Commissioner. In the case of concrete, such permission will not be given until the concrete has been in place 7 days, or until tests made by the Contractor's QC organization and tested by the Contractor's approved laboratory, subject to the verification by the QA laboratory working under supervision of the Commissioner establish that the concrete has attained or exceeded the strength requirements stated within these Specifications in order to provide a factor of safety against damage or strain in withstanding any pressure created by the backfill or the methods used in placing it.
- C. Backfill will be considered as a subsidiary obligation of the Contractor for the structure involved.

3.9 CLEANING AND RESTORATION OF SITE:

- A. All rubbish and debris resulting from the Work of this Section must be collected, removed from the site and disposed of legally. The contractor must restore all disturbed areas to their original condition. Where the original condition is grass, topsoil and sod or permanent seeding must be used for restoration, as shown on the Drawings. All costs of restoration will be included in the Contract unit price.
- B. After all work is completed, the Contractor must remove all tools and equipment, leaving the entire site free, clear, and in good condition.

END OF SECTION 33 05 17

SECTION 33 10 00 - WATER UTILITIES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: This Section specifies requirements for furnishing all labor, material, equipment, and services necessary for Water systems at the locations shown on the Drawings and as specified herein.
- B. Related Work Specified in Other Sections Includes, but is Not Limited to, the Following:
 - 1. Section 02 41 16 – Structure Demolition
 - 2. Section 02 41 18 - Pavement Removal
 - 3. Section 32 11 16 - Subbase Courses
 - 4. Section 32 12 00 - Asphalt Paving
 - 5. Section 32 13 00 - Concrete Paving
 - 6. Section 33 30 00 - Sanitary and Storm Sewerage
- C. Comply with the “American Iron and Steel (AIS)” requirements as contained in Section 436 of the Consolidated Appropriations Act, 2014, further described in Section 01 11 10 Compliance with Iron and Steel Requirements.

1.2 SUBMITTALS

- A. Submit the following:
 - 1. Product Data:
 - a. Provide data on pipe materials, pipe fittings, valves, meters, and accessories.
 - 2. Manufacturer's Certificate:
 - a. Certify that products meet or exceed specified requirements.
 - 3. Pressure test results and disinfection test results.

1.3 REFERENCES

- A. AWWA (American Water Works Association)
- B. ANSI (American National Standards Institute)
- C. Applicable provisions of the Chicago Department of Water Management Design Guidelines and Standard Specifications for Water Main Construction; Standard Details for Water Main Installation
- D. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- E. ASTM B88 Seamless Copper Water Tube
- F. ANSI/ASTM D698 - Test Methods for Moisture - Density Relations of Soils and Soil-Aggregate Mixture, Using 5.5 lb (2.49 Kg) Rammer and 12 inch (304.mm) Drop.
- G. ASTM C478 - Precast Reinforced Concrete Manhole Sections.
- H. AWWA C600 - Installation of Ductile - Iron Water Mains and Appurtenances.

- I. IAWWA C651 - Standards for Disinfecting Water Mains.
- J. Illinois Standards - Standard Specification for Water and Sewer Main Construction in Illinois, Latest Edition.
- K. Chicago Department of Transportation, Regulations for Openings, Construction and Repair in the Public Way, latest edition.
- L. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications".

1.4 REGULATORY REQUIREMENT

- A. Perform work in accordance with City of Chicago, Department of Water Management requirements.
- B. Valves: Manufacturer's name and pressure rating shall be marked on valve body.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with the latest edition of the appropriate divisions, of the following:
 - 1. City of Chicago Department of Water Management Permit Requirement and Fee.
 - 2. Disinfection Standards: Disinfect in accordance with AWWA C651 for water mains.
 - 3. Standard Specifications for Water and Sewer Main Construction, Illinois Society of Professional Engineers.
 - 4. Chlorinated Water Disposal: Dispose of old highly chlorinated water in accordance with IEPA regulations.
 - 5. Manufacturer's Installation Instructions

1.6 WARRANTY

- A. Provide one (1) year warranty or manufacturer's standard warranty, whichever is longer. Warranty period will begin as defined in Specifications Book 1 – Terms and Conditions for Construction.

PART 2 MATERIALS

2.1 DUCTILE IRON PIPE ACCEPTABLE MANUFACTURERS

- A. American Cast Iron Pipe Company
- B. United States Pipe and Foundry Company
- C. Griffin Pipe Product Co.

2.2 DUCTILE IRON PIPE

- A. Ductile iron pipe must conform to the requirements of ANSI Standard A21.51 (AWWA C151), joints to conform to ANSI A21.11 (AWWA C111), and the cement lining conform to ANSI A21.4 (AWWA C104) with the following additions or substitutions:

1. Section 51.2:
 - a. Sub-section 51.2.6 – Make the following addition:
 - (1) Bells must be so designed to afford a watertight joint without additional jointing material and capable of withstanding pressures without leakage exceeding those that will rupture pipe of this class and thickness.
 - (2) All pipe must be supplied with all accessories necessary for the number of pipe lengths delivered.
- B. Exterior of pipe must be coated with a petroleum asphaltic material in conformance with ANSI A21.10 (AWWA C110, Section 10-10). Interior of pipe must be cement lined in accordance with ANSI A21.4 (AWWA C104).
- C. Section 51.10:
 1. Make the following additions:
 - a. Each pipe must be identified with a manufacturing run number traceable for certification.
 - b. Pipe joints must be push-on type joints unless otherwise shown on the Drawings, specified, or directed by the Commissioner. Push-on type joints must conform to ANSI A21.11 (AWWA C111).
 - c. Restrained joints when shown on the Drawings, specified or directed by the Commissioner must be Megalug or mechanical joint restraint glands. Mechanical joints must conform to ANSI A21.10 (AWWA C110).
 - d. Ductile iron pipe supplied by the Contractor must be per ANSI A21.51(AWWA C151) latest revision with thickness class as follows:

<u>Diameter</u>	<u>Class</u>
4 and 6 inches	55
8 to 12 inches	56

- e. The Contractor must submit to the Commissioner certified copies of all test reports.

2.3 DEPTH OF PIPE COVER

- A. Unless otherwise shown on the Drawings, or directed by the Commissioner, all watermains and services must be installed so a minimum pipe cover is provided as described in the following table:

<u>Size of Pipe</u>	<u>Standard Cover and Tolerance</u>
3/4" to 3"	5'-6" ±3"
4"	5'-6" ±3"
6"	5'-6" ±3"
8"	5'-3" ±3"

2.4 FITTINGS

- A. Fittings to be furnished and installed must be Megalug or mechanical joint using retainer glands except as indicated on the Drawings. They must be 250 psi pressure class castings in accordance with ANSI A21.10 (AWWA Standard C110) as revised. Laying lengths, wall thicknesses and variations must be per ANSI A21.10 (AWWA C110). Compact fittings are not allowed.

- B. All gasketing materials must conform to the latest revision of AWWA C-111, and C-110, and ASTM C564 for potable water. Only rubber gaskets must be used.
- C. The Contractor must provide the Commissioner with a written statement that all tests have been made and met as specified.
- D. The fittings must be smooth and free from defects of every nature which would make them unfit for the use which they were intended. No plugging of fittings will be allowed. Repairing of defects by welding will not be allowed.
- E. All castings must be coated inside and outside with a petroleum asphaltic material in conformance with Section 4.3 of AWWA C110 (ANSI A21.10). A cement-mortar lining is not required.
- F. All unfit castings must be removed from the job site by the Contractor and replaced by him with fittings in conformance with the Specifications at no cost to the City.
- G. Every casting must have distinctly cast upon it the initials of the manufacturer's name. Each casting must also have cast upon it figures showing the year in which it was cast and a number signifying the order in which it was cast, thus:

15	15	15
1	2	3

- H. The letters and figures must be cast on the outside and must not be less than one inches in length.
- I. The Contractor must furnish all necessary rubber joint gaskets, joint lubricant, nuts and bolts and sets of other equipment, special tools, and accessories that may be required to assemble pipe and fittings.

2.5 GASKETS

- A. All gaskets for pipe, fittings, and appurtenances must be vulcanized natural or vulcanized synthetic rubber, non-porous, free of foreign materials and visible defects. Recycled rubber must not be used.
- B. When soil conditions do not permit the use of natural or synthetic rubber gaskets and when directed by the Commissioner, all gaskets for pipe, fittings, and appurtenances must be Nitrile (acrylonitrile butadiene), non-porous, free of foreign materials and visible defects.
- C. Gaskets for flanged joints must be of the ring type meeting the requirements of ANSI Standard B16.21. Gaskets must be made by the Crane Company, Garlock Packing Company, U. S. Rubber Company, or approved equal. Gaskets must be 1/16 inch thick.
- D. Gaskets must be stored in a cool place and protected from light, heat, oil, or grease until installed. Any gasket showing signs of cracking, weathering, abrasion, or other deterioration will be rejected.

2.6 POLYETHYLENE ENCASEMENT

- A. Polyethylene encasement material must be 4-mil, cross laminated, high-density polyethylene tubing in accordance with AWWA C105.

2.7 WATER SERVICE PIPE

- A. Copper Tubing: ASTM B88, Type K, annealed:
 - 1. Fittings: ANSI/ASME B16.22, wrought copper, ANSI/ASME B16.22, wrought copper.
 - 2. Joints: Compression connection of ANSI/AWS A5.8, B Cup silver braze.

2.8 STOP AND BOXES

- A. Curb stops and corporation stops shall be ball valves with brass body, Teflon coated brass ball, rubber seats and stem seals, tee stem pre-drilled for control rod. Stop shall be Standard City of Chicago valves manufactured by Mueller Brass Company, A.Y. McDonald, EJ Prescott.
- B. Service box shall be in accordance with City of Chicago Standards.
- C. Cover of extension service box shall be marked "WATER" with raised letters.

2.9 WATER METER (REFER TO PLUMBING DRAWINGS FOR SIZE)

- A. Water Meter installed in the Building, water meter room, per City of Chicago Standard and as shown of the Plumbing Drawings.

2.10 BEDDING MATERIALS

- A. Coarse aggregate, gradation CA-16 per Article 1004 of IDOT Standard Specification.

2.11 TRENCH BACKFILL

- A. Fine aggregate, gradation CA-16 per Article 1003 of IDOT Standard Specification.

2.12 CONCRETE THRUST BLOCKS

- A. Concrete thrust blocks shall be IDOT Class SI concrete pavement per Article 1020.04 of the SSRBC, per details provided on the plans.

PART 3 EXECUTION

3.1 PERMIT

- A. Obtain permit from Department of Buildings Water Permits prior to starting work.

3.2 EXAMINATION

- A. Verify that municipal utility water main size and location are as indicated on the Drawings.
- B. Install pipe and valves according to AWWA C600.

3.3 GENERAL

- A. The Contractor must coordinate all water system work with the Department of Water Management. The Contractor is responsible for removal of pipe and installation of new pipe, which includes but is not limited to trench excavation, shoring, pipe supports and dewatering. The Contractor must do all excavations to install the systems to the lines and grades or elevations shown on the Contract Drawings, including excavation at the main for the Department of Water Management to install the taps. The excavation must be of sufficient size to permit the placing of the full width and length of the structure or structure footing shown.
- B. Boulders, logs, or any other objectionable material encountered in excavation must be removed. All rock or other hard foundation material must be cleaned of all loose material and cut to a firm surface. Rock or other unsuitable material must be removed and replaced with fine aggregate trench backfill. The foundation for the structure must be undisturbed ground with a minimum of 6 inches of fine aggregate trench backfill.
- C. The Contractor must furnish and install all temporary earth retention necessary to implement and protect the excavation and the structures as required for safety or conformance to governing laws. The temporary earth retention system will be included in this work.

Unless otherwise provided, temporary earth retention system involved in the construction of this item must be removed by the Contractor after the completion of the structure. Removal must be effected in a manner which will not disturb or mar finished masonry. After each excavation is completed, the Contractor must notify the Commissioner to that effect; and concrete or reinforcing steel must be placed after the Commissioner has approved the depth of the excavation and the character of the foundation material.

- D. The Contractor must verify the required minimum bearing beneath the concrete structure. Contractor QC to verify bearing to 3 feet minimum or to depth as directed by the Commissioner. The cost of verifying the required bearing will be considered included and incidental to the price of the structure.
- E. Where suitable bearing conditions is not encountered at subgrade indicated for footings, foundations and manholes/catch basins, the Commissioner may direct additional excavation and backfill with stabilization stone as necessary.
- F. The Contractor is responsible for backfilling all excavations for the water system, including excavations required for the Department of Water Management to make the taps from the main.

3.4 WATER MAIN AND SEWER SEPARATION

- A. The water mains shown on the Contract Drawings have been located and designed to be in accordance with Illinois Standards regarding sewer and water main separation.
- B. If a sewer is encountered during construction which has not been shown and which is closer than 10 feet horizontally and less than 18 inches below the bottom of the Water main, or is above the water main, construction must be as follows:
 - 1. If the sewer is parallel to the water main, the sewer must be re-constructed of materials and with joint equivalent to water main standards of construction, and must demonstrate water tightness.

2. When a new water main crosses under a new or existing sewer, the water main must be sleeved in an encasing pipe for a minimum distance of 10' - 0" on each side of the sewer centerline. The encasing pipe must be as described in paragraph 3.11 of this Section and must be watertight and of sufficient inside diameter to pass the bells/joints of the water main. Further, the encasing pipe must be designed to support any load imposed by the filled water main, the sewer, the overburden, and anticipated live loads. The water main must be provided with insulating sled type spacers to insure that the water main is connected in the encasing pipe. Ends of the encasing pipe must be sealed.

3.5 PREPARATION FOR TAPPING & CONNECTION

- A. Notify and coordinate new taps with Department of Water Management. The Department of Water Management will execute the tap and provide a point of continuation for the Contractor.

3.6 BEDDING

- A. Excavate pipe trench and hand trim excavation for accurate placement of pipe to elevations indicated.
- B. Place bedding material at trench bottom in layers not exceeding 6-inch loose lifts, compact to 95 percent of maximum dry density ASTM D-1557.
- C. Backfill around sides and to top of pipe with fill tamped in place and compacted to 95 percent of maximum dry density ASTM D-1557.
- D. Maintain optimum moisture content of bedding material to attain required compaction density.

3.7 INSTALLATION - PIPE

- A. Installation by a licensed plumber.
- B. Maintain separation of water main from sewer piping in accordance with Illinois Standards and Section 3.4.
- C. Protective water main polyethylene wrap (polywrap), 4 mils minimum thickness, cross laminated, is to be installed on all ductile iron pipe and fittings and secured with 2 inch compatible adhesive tape at all seams. The polyethylene tubing must comply with AWWA C105.
- D. Install pipe to indicated elevation.
- E. Route pipe to indicated elevation.
- F. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- G. Install access fitting to permit disinfection of water system.
- H. Form and place concrete for thrust block at each elbow or change or direction of pipe main.
- I. Establish elevations of buried piping to ensure not less than 5' of cover.
- J. Backfill trench with trench backfill.

3.8 INSTALLATION - VALVES

- A. Set valves on solid bearing.
- B. Center and plumb valve box over valve. Set box cover flush with finished grade.

3.9 TAP SERVICE CONNECTIONS

- A. Coordinate new taps with the Department of Water Management, which will be provided by the Department. Provide any excavation required for the Department to access main for tapping.

3.10 THRUST BLOCK INSTALLATION

- A. Install thrust blocks on plugs, tees and bends $22\frac{1}{2}^{\circ}$ or greater.
- B. Place concrete between undisturbed earth and the fitting to be anchored. Place concrete so that the pipefitting and joints are accessible for repair.
- C. Size thrust blocks to prevent movement for soil conditions and pressure ratings.

3.11 WATER PIPE IN CASING PIPE

- A. Steel casing pipe must have a minimum wall thickness of 3/8 inch and joints must be continuously welded.
- B. The casing pipe must be watertight and of sufficient inside diameter to pass the bells/joints of the water main. Further, the encasing pipe must be designed to support any load imposed by the filled water main, the sewer, the overburden, and anticipated live loads. The water main must be provided with insulating sled type spacers to insure that the water main is connected in the encasing pipe. Ends of the encasing pipe must be sealed with Thunderline Corporation "Link- Seals" or by other approved means.

3.12 PLACE CONCRETE BETWEEN UNDISTURBED EARTH AND THE FITTING TO BE ANCHORED.
PLACE CONCHYDROSTATIC TESTS

- A. Conform to City of Chicago Plumbing Code and AWWA C-600, Section 4.
- B. The Contractor shall be responsible for testing, shall furnish the Commissioner with written test results, and shall have the Commissioner witness the tests, after providing 24 hours notice.
- C. Pressure Test:
 - 1. Test water mains to be used for domestic service to a minimum pressure of 100 psi over a two-hour period.
 - 2. Test pressure shall not vary by more than ± 5 psi for the duration of the tests.
 - 3. Fill each valve section of pipe with water slowly. Expel air completely from pipe and valves.
 - 4. Apply test pressure based on lowest elevation of main.
 - 5. All pressure tests will require a report from the Contractor's Q.C. Department. The Commissioner will witness tests after 24 hours notice was provided to the Commissioner.

D. Leakage Test:

1. Perform leakage test concurrently with pressure test.
2. The allowable leakage shall not be greater than that determined by the following formula:

$$L = \frac{ND P^{0.5}}{7400} \quad \text{or} \quad L = \frac{SD P^{0.5}}{132,200}$$

L = The allowable leakage in gallons per hour
N = Number of joints in length of pipeline tested
D = The nominal diameter of pipe in inches
P = Average test pressure during the leakage test in psi
S = Length of pipe tested in feet

3. All leakage tests will require a report from the Contractor's Q.C. Department. The Commissioner will witness tests after 24 hours notice was provided to the Commissioner.

E. Repair or replace failed sections after each test.

3.13 DISINFECTION

- A. Preliminary Flushing: Prior to chlorination and after pressure test, flush main as thoroughly as possible with the water pressure and outlets available.
- B. Disinfection: Disinfect and test according to the requirements of AWWA C651, the Illinois Standards and City of Chicago Department of Water Management Standards.
- C. Final Flushing: Following chlorination, flush treated water.

END OF SECTION 33 10 00

SECTION 33 22 05 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies requirements for the construction of an approved aggregate base course. The work shall include furnishing all labor, materials, tools, and equipment required for the construction of the aggregate base course.
- B. Related Requirements:
 - 1. Section 32 12 16 "ASPHALT PAVING"
 - 2. Except as modified herein, the work shall conform to the applicable portions of the Standard Specifications, Section 351.

1.3 SUBMITTALS

- A. The Contractor shall submit to the Engineer a sample of the aggregate to be used for testing of acceptability and compactability.

PART 2 - PRODUCTS

- 2.1 The Aggregate used for this project shall be crushed gravel, meeting all the applicable requirements of Article 1004.01 of the Standard Specifications.

PART 3 - EXECUTION

- 3.1 Prior to the placement of the base course material, the subgrade shall be prepared in accordance with Section 301 of the Standard Specifications.
- 3.2 Aggregate Base Course shall be compacted in accordance with Article 351.05 (b) of the Standard Specifications.
- 3.3 Contractor shall notify the Engineer two days in advance of base course placement to allow for scheduling of density measurements. If measurements indicate a need for additional compaction the Contractor shall follow the requirements of Article 351.5 of the Standard Specifications.

END OF SECTION 33 22 05

SECTION 33 30 00 - SANITARY AND STORM SEWERAGE

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Furnish and install all labor, materials, tools, and equipment required for furnishing and installing Sanitary and Storm Sewer pipe, including, but not necessarily limited to, trench excavation and disposal of all unsuitable material; special fabrication and field installation of pipe; connections to existing sewers and manholes; modifications of existing sewers; bedding; backfilling of trenches with specified trench material; and other appurtenant or related work associated with the construction of sanitary and storm sewers as shown on the Plans.
- B. Related Work Specified In Other Sections Includes, But is Not Limited to, the Following:
 - 1. Section 01 10 00 - Summary of Work
 - 2. Section 31 20 00 - Earth Moving
 - 3. Section 32 12 00 - Asphalt Paving
 - 4. Section 32 13 00 - Concrete Paving
 - 5. Section 33 47 00 – Adjustment and Repair of Existing Utility Structures
 - 6. Section 33 05 17 - Sewer Structures
 - 7. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. “Standard Specifications”. This work shall be performed in accordance with the applicable portions of the Standard Specifications, Sections 550”. Articles of the Standard Specifications covering “Method of Measurement” and “Basis of Payment” are not applicable.

1.2 REFERENCES

- A. Chicago Department of Transportation, Regulations for Openings, Construction and Repair in the Public Way, latest edition.
- B. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. “Standard Specifications”.
- C. ASTM C12 - Practice for Installing Vitrified Clay Pipe Lines.
- D. ASTM C14 - Specification for Concrete Sewer, Storm Drain and Culvert Pipe.
- E. ASTM C 76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- F. ASTM C 425 – Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
- G. ASTM C 443 – Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
- H. ASTM C 700 – Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.

- I. ACI 318 - Building Code Requirements for Reinforced Concrete
- J. ASTM C478 - Standard Specifications for Precast Reinforced Concrete Manhole Sections.
- K. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- L. City of Chicago, Department of water Management, Standard Specification for Water and Sewer Main Construction, latest edition
- M. Standard Specification for Water and Sewer Main Construction in Illinois (SSWSMC).

1.3 SUBMITTALS

- A. Submit the following:
 - 1. Test Reports
 - a. Submit test reports necessary to show compliance with the Contract Documents.
 - 2. Manufacturer's Certification
 - a. Submit certification that products meet or exceed the specified requirements.
 - 3. Operation and Maintenance Manuals
 - a. Provide maintenance instruction.

1.4 WARRANTY

- 1. The storm sewer structures shall be warranties for at least five (5) years or manufacturer stander if longer from any damage or structural imperfections that could cause maintenance for the City of Chicago.

1.5 DELIVERY, STORAGE AND HANDLING

- 1. Delivery, storage and handling must be done in such a manner to prevent damage to the segments.
- 2. Precast sections must not be shipped nor subjected to loading until compressive strength has attained 3,000 pounds per square inch (PSI) or five days after fabrication, whichever is longer.
- 3. Base, riser, cone and flat top precast sections, frames and covers must be delivered to site when required by approved project schedule.

1.6 QUALITY ASSURANCE

- A. Contractor Qualifications: Installation of sanitary sewer must be performed only by a qualified Installer. The term qualified means experienced in performing the Work required by this Section. The Contractor must have substantial number of years documented experience in Projects similar in size and scope to this Project. The Contractor must submit evidence of such qualifications upon request by the Commissioner.
- B. Prior to the start of work, permits are required from the City of Chicago Department of Building – Water and Sewer Section for the installation of sewers. A Department of Water Management permit must be obtained only by a Licensed Drain Layer possessing a current Sewer and Drain License issued by the Department of Water Management.

C. Perform Work in accordance with the latest edition, of the appropriate divisions, of the following:

1. City of Chicago Department of Water Management Permit Requirement and Fee
2. Standard Specification for Water and Sewer Main Construction, Illinois Society of Professional Engineers

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

A. Extra Strength Vitrified Clay Pipe

1. Vitrified clay pipe and fitting must be extra strength clay bell and spigot pipe conforming to the requirements of ASTM C700.
2. Vitrified clay pipe joints must be resilient, compression-type joints conforming to ASTM C425. Joints may be provided in one of the following ways:
 - a. Joints made of polyurethane must have an integral compression ring formed as part of the factory made joint.
 - b. Where rubber gaskets are used, they must be continuous precision molded gaskets manufactured from a compound containing a basic polymer of not less than 50% by volume of isoprene and must contain no vulcanized vegetable oil, reclaimed rubber or dry deleterious substance.

B. Reinforced Concrete Pipe

1. Circular reinforced concrete pipe and fittings must conform to the requirements of ASTM C76, Class IV, Wall B with circular reinforcement.
2. Preformed tapered holes of the proper dimensions as shown on the Plans for the connection of drains and future drain connections must be provided during the manufacture of the pipe. Tapered holes must be so formed that the drain connection will enter the sewer at an angle of approximately 90 degrees with the axis of the sewer. Whenever the diameter of a preformed tapered hole is equal to or exceeds 50 percent of the diameter of the pipe, additional reinforcement steel satisfactory to the Commissioner must be placed around the hole.
3. Reinforced concrete pipe joints must be flexible rubber gasket joint type conforming to ASTM C361, ASTM C443 and AASHTO M198.

2.2 DISSIMILAR PIPE COUPLING:

- A. When one pipe material is to join another pipe material and the change in pipe material will not occur at a manhole, the dissimilar pipes must be joined using a "band-seal" adapter coupling.
- B. For sewer pipes larger than 15 inches in diameter, transitions between different pipe materials must be as directed by the City of Chicago Department of Water Management – Bureau of Engineering Services.

PART 3 EXECUTION

3.1 GENERAL:

- A. All pipe, fittings, and appurtenances must be installed in accordance with the manufacturer's recommendations and requirements.
- B. All pipe, fittings, and accessories must be delivered, unloaded, strung, and laid as specified here.

3.2 PREPARATION FOR LAYING PIPE:

- A. Materials, coatings, and linings must be as specified and as shown. Installation must be in accordance with standards as recommended by the pipe manufacturer, and as specified here.
- B. Proper and suitable tools and appliances for the safe and convenient cutting, handling, and laying of the pipe and fittings must be used.
- C. Before lying, all pipe and fittings must be thoroughly examined for defects and no piece may be installed which is known to be defective. If defects are discovered after pipe or fittings have been installed, the Contractor must remove the defective pipe or fitting and replace it with a sound one in a satisfactory manner.
- D. The pipe and fittings must be thoroughly cleaned before they are laid and must be kept clean until they are accepted in the finished work. Care must be exercised to avoid leaving bits of wood, dirt, rock and other foreign particles in the pipe. If any such materials are discovered before the final acceptance of the work, they must be removed and the pipe and fittings replaced, if necessary. All pipes must be kept absolutely clean during construction and must be stopped off with night plugs at the end of each day's work.
- E. Excavate pipe trenches as specified in Section 31 20 00 "Earth Moving." Hand trim bottom of trench to six (6) inches below bottom of pipe.
- F. Place and compact pipe bedding as specified in Section 31 20 00 "Earth Moving."
- G. Keep trench bottom free from excess water. If the trench bottom is unsuitable for the pipes foundation, the kind of stabilization to be utilized will be ordered in writing.

3.3 EXCAVATION

- A. The width of the pipe trench must be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe, but not be less than the external diameter of the pipe plus 6 inches on each side. The trench walls must be approximately vertical except where safety considerations require benching of the trench walls.
- B. Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, the unstable soil must be removed and replaced with stabilization stone for the full trench width. The Commissioner must determine the depth of removal necessary. The granular material must be compacted to provide adequate support for the pipe in accordance with Section Section 31 20 00 "Earth Moving."

- C. The excavation for pipes that are placed in embankment fill must not be made until the embankment has been completed to a height above the top of the pipe as shown on the Drawing.
- D. The Contractor must construct such trench bracing, sheathing, or shoring necessary to perform and protect the excavation as required for safety and conformance to governing laws. The bracing, sheathing, or shoring must not be removed in one operation but must be done in successive stages to prevent overloading of the pipe during backfilling operations. The cost of bracing, sheathing, or shoring, and the removal of same, must be included in the unit price for the pipe.

3.4 PLACEMENT:

- A. Sewers must be laid to the lines and grades shown on the Contract Drawings.
- B. The pipe laying must begin at the downstream end of the pipe. Install pipe so that bells and grooves are on the upstream end. Install vitrified clay pipe in accordance with the requirements of ASTM C12.
- C. Prevent dirt, rock and other foreign particles from getting into the open end of the pipe and any pipe joints.
- D. Clean interior of pipe of cement, dirt and extraneous material as the work progresses.
- E. Lateral and service connections are to be made with manufactured wye fittings or preformed tapered holes or field cored holes.
- F. Maintain separation of detention system from water piping in accordance with Illinois Standards.
 - 1. Horizontal: 10 feet minimum (Outside of Pipes)
 - 2. Vertical: 18 inches minimum (Outside of Pipes)

3.5 BEDDING AND BACKFILLING:

- A. Sewers laid in trenches must be installed on bedding and backfilled in accordance with the details shown on the Contract Drawings and bedded and backfilled per Section 31 20 00 "Earth Moving" of these Specifications.

3.6 PIPE JOINTS:

- A. Pipe joints must be made secure and watertight.
- B. Employ appropriate equipment to draw the sections of the pipe tightly together.
- C. Apply lubricant to rubber gaskets immediately before joining pipe sections.
- D. Joints of bell-and-spigot pipe and tongue and groove pipe must be filled with cement mortar so as to make a strong and watertight joint. Finish joints smooth on inside of pipe with cement mortar.
- E. Inside joint recesses of pipe shall be filled with cement mortar prior to closure of the joint. After closure is made, the joint must be pointed inside of the pipe and excess mortar removed.
- F. Inspect each joint for proper assembly prior to backfilling.

- G. Mortar joints used for connections to existing sewer pipes or house drains may be used only when connections cannot be made using gasketed joints as specified or the appropriate pipe adaptor as supplied or recommended by the pipe manufacturer, or as directed otherwise by the Owner.
- H. When mortar joints are required, they must be constructed to the following standards:
 - 1. Center spigot of pipe in the socket using a packing gasket of twisted impregnated oakum of proper thickness and sufficient length to pass around the pipe and lap the top.
 - 2. After the pipe has been placed, caulk the gasket into the annular space and fill the remainder of the space with Portland cement mortar beveled off with the outside of the socket.
 - 3. Mortar for pipe joints or fittings must be made of one (1) part Portland Cement and one (1) part sand conforming to applicable requirements of Section 03 30 00 – Cast In Place Concrete.
 - 4. Only a sufficient amount of mortar may be prepared for use within forty-five (45) minutes of application. Any mortar that has begun to set must not be used.
 - 5. As each joint is completed, thoroughly clean the inside of the pipe to remove all excess joint material.

3.7 EQUIPMENT:

- A. All equipment necessary and required for proper construction of storm drains must be on the Project, in first-class working condition, and approved by the Owner before construction is permitted to start.
- B. The Contractor must provide appropriate hoisting equipment to handle the pipe while unloading and placing it in the final position without damage to the pipe.
- C. The Contractor must provide vibratory means to obtain the required compaction of the aggregate pipe bedding and backfill as specified in Section 31 20 00 "Earth Moving" of these Specifications.

3.8 CONNECTIONS TO STRUCTURES AND PIPES:

- A. Where the Drawings show connections to existing or proposed pipe or structures, these connections must be watertight and made so that a smooth uniform flow line must be obtained throughout the drainage system.

3.9 INSPECTION:

- A. Prior to final acceptance of the drainage system, the Commissioner, accompanied by the Contractor, must make a thorough inspection by an appropriate method of the entire installation. Defects in material or workmanship or obstruction to the flow in the pipe system must be corrected by the Contractor without additional compensation as directed by the Commissioner.
- B. For pipes smaller than 72 inches in diameter, an internal television inspection must be performed by the Contractor following the completion of installation and backfill compaction testing showing a complete, clean installation. Any debris or deficiencies encountered must be cleaned or repaired, to the satisfaction of the Commissioner, and the segment(s) must be re-televised showing a complete, clean installation. The television camera used must be high-resolution color, must be equipped with a revolving head, and must be equipped with a footage counter which records on the video recording. Video recordings in DVD format must be made of the internal inspection and submitted to the Commissioner. The costs

associated with televising must be considered incidental and no additional payment will be made for this work.

- C. Mandrel all sanitary sewers with a 95% go/no-go mandrel in the presence of and to the approval of the Commissioner. Mandrelling must be performed a minimum of 30 days after completion of the sewer installation and all backfilling operations.
- D. After the pipes have been mandrelled and cleaned of all dirt and foreign materials, the pipe lines, as a whole or in convenient sections, must be tested by plugging the section to be tested and applying a starting gauge pressure of 4 psi, let stabilize, then start test at 3.5 psi and have pressure drop no more than 1 psi in time allotted per ASTM C828 - Standard Test Method for Low-Pressure Air Test. Any observed leaks must be repaired as directed by the Commissioner at the expense of the Contractor and that Section retested to the satisfaction of the Commissioner.
- E. Prior to turnover of the completed installation, and a minimum of 30 days after completion of backfilling operations, the interior of all sanitary sewers, service connections, and structures must be televised in the presence of the Commissioner showing a complete, clean installation. Any debris or deficiencies encountered must be cleaned or repaired, to the satisfaction of the Commissioner, and the segment(s) must then be re-televised showing a complete, clean installation. The television camera used must be high-resolution color, must be equipped with a revolving head, and must be equipped with a footage counter which records on the video recording. Submit the video recording in DVD format to the Commissioner for viewing, acceptance and for the Project files. The costs associated with televising, cleaning, and repair must be considered incidental to the installation of the sanitary sewer and no additional payment will be made for this work.

3.10 IDENTIFICATION:

- A. Types, sizes and classes of pipes must be as shown on the Contract Drawings, and as provided herein.

3.11 DISPOSAL OF MATERIALS:

- A. Surplus materials must be disposed of in accordance with the Specifications

3.12 GENERAL CLEAN-UP:

- A. All rubbish and debris resulting from the Work of this Section must be collected, removed from the site and disposed of legally.
- B. All work areas must be left in a broom clean condition.

END OF SECTION 33 30 00

SECTION 33 47 00 - ADJUSTMENT AND REPAIR OF EXISTING UTILITY STRUCTURES

PART 1 GENERAL

1.1 SUMMARY

- A. This section includes adjusting, cleaning, and repairing sewer or storm manholes, catch basins and inlets in accordance with the specifications herein.
- B. Related Requirements:
 - 1. IDOT Standard Specifications for Road and Bridge Construction, Latest Edition. "Standard Specifications". This work shall be performed in accordance with the applicable portions of the Standard Specifications, Sections 602 and 1020. Articles of the Standard Specifications covering "Method of Measurement" and "Basis of Payment" are not applicable.

1.2 SUBMITTALS

- A. Contractor shall submit to the Owner plant certification for the hot-mix asphalt supplier along with the proposed mix design for approval prior to any surfacing operations.

PART 2 PRODUCTS

2.1 CONCRETE

- A. Plain and reinforced concrete used in structures, connections of pipes with structures, and the support of structures or frames shall be IDOT Class SI.

2.2 MORTAR

- A. The mortar must be composed of 1 part of Portland cement and 2 parts of mortar sand by volume. The Portland cement must conform to the requirements of AASHTO M 85. The sand must conform to the requirements of AASHTO M 45. Hydrated lime may be added to the mixture of sand and cement in an amount not to exceed 15% of the weight of cement used. The hydrated lime must meet the requirements of ASTM C 206. The water must be clean and free of deleterious amount of acids, alkalis, or organic material. If the water is of questionable quality, it must be tested in accordance with AASHTO T 26.

2.3 GRADE RINGS

- A. Pre-cast concrete grade rings must meet the requirements of ASTM C478.

2.4 BEDDING MATERIAL

- A. Bedding under bases or foundations must be fine aggregate trench backfill in accordance with Section 31 23 36 "Sand Fill".

PART 3 EXECUTION

3.1 GENERAL:

- A. The Contractor must do all excavation of structures and structures footings to the lines and grades or elevations shown on the Contract Drawings. The excavation must be of sufficient size to permit the placing of the full width and length of the structure or structure footing shown.
- B. Boulders, logs, or any other objectionable material encountered in excavation must be removed. All rock or other hard foundation material must be cleaned of all loose material and cut to a firm surface. Rock or other unsuitable material must be removed and replaced with fine aggregate trench backfill. The foundation for the structure must be undisturbed ground with a minimum of 6 inches of fine aggregate trench backfill.
- C. The Contractor must furnish and install all temporary earth retention necessary to implement and protect the excavation and the structures as required for safety or conformance to governing laws. The temporary earth retention system will be included in this work.
- D. Unless otherwise provided, temporary earth retention system involved in the construction of this item must be removed by the Contractor after the completion of the structure. Removal must be effected in a manner which will not disturb or mar finished masonry.

3.2 PLACEMENT AND TREATMENT OF CASTINGS, FRAMES, AND FITTINGS:

- A. All castings, frames, and fittings must be placed in the positions indicated on the Plans or as directed by the Owner, and must be set true to line and to correct elevation, all anchors or bolts must be in place and position before the concrete or mortar is placed. The unit will not be disturbed until the mortar or concrete has set.
- B. When frames or fittings are to be placed upon previously constructed masonry, the bearing surface or masonry must be brought true to line and grade and must present an even bearing surface in order that the entire face or back of the unit must come in contact with the masonry. The unit must be set in mortar beds and anchored to the masonry as indicated on the Contract Drawings or as directed and approved by the Owner. All units must be set firm and secure.
- C. After the frames or fittings have been set in final position and the concrete or mortar has been allowed to harden for 7 days, then the grates or covers must be placed and fastened down.
- D. When pre-cast concrete grade rings are used to reset frames to a new elevation, no more than four rings may be used. Total adjustment must be no more than 12 inches.

3.3 ADJUSTMENT OF STRUCTURES

- A. Manholes or Catch basin structures requiring vertical adjustment must be brought to proposed grade by either adding or removing concrete adjustment rings as required. Mortar must be placed between each layer of adjusting rings and must be composed of one-part masonry cement to three parts sand, by volume. Frames must be set firm, secure, true to line and to the correct elevations. This adjustment will include centering and adjusting the grade of existing frame and sealing the frame on the existing structures. Frames and Grade adjusting rings will be installed with mastic to prevent seepage of water into the manhole. Grade shall be established as a minimum of 1% from the lowest point on the existing adjacent pavement.

- B. When precast concrete adjusting rings are used to adjust frames to proposed or new elevation, no more than four rings may be used. Total adjustment must be no more than 12 inches.
- C. Adjustments in excess of one foot must have new precast riser sections installed. All required riser sections must be considered included in the adjustment of the structures.

3.4 BACKFILLING:

- A. After a structure has been completed, backfill in accordance with the requirements of the detailed Drawings and Section 31 20 00 – Earth Moving.
- B. Backfilling must not be placed against any structure until permission is given by the Owner. In the case of concrete, such permission will not be given until the concrete has been in place 7 days, or until tests made by the Contractor's QC organization and tested by the Contractor's approved laboratory, subject to the verification by the QA laboratory working under supervision of the Owner establish that the concrete has attained or exceeded the strength requirements stated within these Specifications in order to provide a factor of safety against damage or strain in withstanding any pressure created by the backfill or the methods used in placing it.
- C. Backfill will be considered as a subsidiary obligation of the Contractor for the structure involved.

END OF SECTION 33 47 00



Geotechnical Engineering Report
Westside Learning Center Building Addition
Chicago, Illinois
November 15, 2018
Terracon Project No. MR185178

Prepared for:
Bailey Edward Design, Inc.
Chicago, Illinois

Prepared by:
Terracon Consultants, Inc.
Chicago, Illinois

terracon.com

Terracon

Environmental



Facilities



Geotechnical



Materials

November 15, 2018

Bailey Edward Design, Inc.
35 E. Wacker Drive, Suite 2800
Chicago, Illinois 60601



Attn: Mr. Zachary Clark, AIA, LEED AP
P: (312) 789-4008
E: ZClark@baileyedward.com

Geotechnical Engineering Report
Westside Learning Center Building Addition
4642 W. Madison Street
Chicago, Illinois
Terracon Project No. MR185178

Dear Mr. Clark:

We have completed our geotechnical engineering evaluation for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PMR1851784 dated May 11, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

A handwritten signature in dark ink, appearing to read "D. Mabirizi".

Daniel B. Mabirizi, E.I.T.
Senior Staff Engineer

A handwritten signature in dark ink, appearing to read "Paul A. Tarvin".

Paul A. Tarvin, P.E.
Regional Geotechnical Manager



REPORT TOPICS

REPORT SUMMARY	I
INTRODUCTION	1
SITE CONDITIONS	1
PROJECT DESCRIPTION	2
GEOTECHNICAL CHARACTERIZATION	2
EARTHWORK	3
SHALLOW FOUNDATIONS	7
FLOOR SLABS	10
SEISMIC CONSIDERATIONS	11
GENERAL COMMENTS	12

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

SITE LOCATION AND EXPLORATION PLANS

EXPLORATION RESULTS

Boring Logs

SUPPORTING INFORMATION

General Notes

Unified Soil Classification System

REPORT SUMMARY

The following items represent a brief summary of the findings of our subsurface exploration and our geotechnical recommendations for the proposed Westside Learning Center building addition project. This summary should be reviewed in conjunction with the complete report.

- n Approximately 5 to 10 inches of topsoil was encountered at the surface. Fill soils consisting of gravel, sand, and lean clays were encountered in boring B-1 and extended to a depth of about 6 feet below existing grade. The underlying native subsurface soils consisted of very stiff to hard lean clays to the termination depth of the borings (approximately 25 feet).
- n Groundwater was encountered in boring B-2 while drilling at a depth of about 19 feet below existing grade. Groundwater was not encountered at boring B-1 during or upon completion of drilling.
- n The proposed building addition may be supported on shallow foundations bearing on the native very stiff to hard lean clays. A maximum net allowable bearing pressure of 3,000 pounds per square foot (psf) may be used for footings. Exterior foundations should be supported at a minimum embedment depth of 4 feet below final grade for frost considerations. To reduce the potential of unpredictable foundation performance and larger than expected settlements, footings excavations should extend through the existing gravel, sand, and lean clay fill and expose the undisturbed native lean clays below having adequate strength to support the foundations. The footings could then be constructed at this lower elevation on the native clays, or the over excavations could be backfilled with structural fill or lean concrete to the design footing elevation. In areas outside of the existing fill, native very stiff clay soils are likely to be encountered at the proposed footing elevation. These soils are also suitable for support of shallow foundations. The **Shallow Foundations** section addresses support of the structures bearing on suitable structural fill, lean concrete, or the native clays.
- n Support of floor slabs on or above existing fill materials is discussed in this report. Based on the Standard Penetration Test (SPT) values and the moisture content test data, it appears that the fill was placed with at least some compactive effort. However, we have not been provided documentation to support this assumption. Therefore, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. Provided the owner is willing to accept the risks associated with supporting floor slabs over the existing fill materials in exchange for reduced construction costs, portions of the existing undocumented fill could be left in place for support of floor slabs. If the owner is not willing to accept the risks of supporting floor slabs over existing undocumented fill materials, the existing fill should be completely removed and replaced.

Geotechnical Engineering Report

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178



- n The **Floor Slabs** section addresses support of slabs on grade on the existing fill soils, newly placed structural fill, or native soils. These soils must be thoroughly tested and observed, and the finished slab subgrades must be prepared as recommended in the **Earthwork** section.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The **General Comments** section provides an understanding of the report limitations.

Geotechnical Engineering Report
Westside Learning Center Building Addition
4642 W. Madison Street
Chicago, Illinois
Terracon Project No. MR185178
November 15, 2018

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed construction of a building addition on a site located at 4642 W. Madison Street in Chicago, Illinois. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification per IBC

The geotechnical engineering scope of services for this project included the advancement of two (2) test borings a depth of about 25 feet below existing site grades in the proposed building addition area.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section of this report.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project site is located at 4642 W. Madison Street in Chicago, Illinois. See Site Location
Existing Improvements	Existing building and associated pavements, landscape areas, and fence around the property. We understand that the existing building has a basement.

Geotechnical Engineering Report

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178



Item	Description
Current Ground Cover	Grass
Existing Topography	Relatively flat

PROJECT DESCRIPTION

Our understanding of the project is as follows:

Item	Description
Proposed Structure	A one-story building addition with a footprint of about 5,200 square feet. The addition will be of typical slab-on-grade construction (no basement).
Building Construction	Metal stud with brick veneer and metal panel type. The structural frame will be steel with a metal deck.
Finished Floor Elevation	About 1 foot above existing grade and match the finished floor elevation of the existing building.
Maximum Loads (assumed by Terracon)	<ul style="list-style-type: none">Columns: 100 kipsWalls: 3 kips per linear foot (klf)Slabs: 150 pounds per square foot (psf)

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization forms the basis of our geotechnical calculations and evaluation of foundation options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

Subsurface Profile

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency/Density
Surface	0.4 to 0.8	Topsoil	N/A
1 ³	6	Fill – Gravel, Sand, and Lean Clay	Hand penetrometer: 2.5 tsf N-value ⁴ : 14 to 23 bpf
2	25	Lean Clay and Silty Clay	Very Stiff to Hard Hand penetrometer: 2.5 to 5.25 tsf N-value: 7 to 24 bpf

-
1. Encountered in boring B-1 only.
 2. N-values = standard penetration resistance values, indicated in blows per foot (bpf).
-

Conditions encountered at each boring location are indicated on the individual boring logs shown in the **Exploration Results** section and are attached to this report. Stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was encountered at boring B-2 while drilling at a depth of about 19 feet below existing grade. Groundwater was not encountered in boring B-1 during or after completion of drilling. However, this does not necessarily mean the boring terminated above groundwater. Due to the low permeability of the soils encountered in the boring, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Another method used to estimate the level of the water table in fine grained soils is to observe the change in color from brown to gray. Fine grained soils are typically brown above the water table where they have been oxidized, and gray below. The change in color occurred at depths of about 6 to 8.5 feet.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

EARTHWORK

Earthwork will include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for foundations and floor slabs.

Site Preparation

The existing vegetation, topsoil, and other debris/unsuitable material should be completely removed from the proposed construction areas. Proper site drainage should be maintained during

Geotechnical Engineering Report

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178



construction so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access.

As noted in **Geotechnical Characterization**, existing fill was encountered in boring B-1 and extended to a depth of about 6 feet below existing grade. Fill soils may be present at other locations and at varying depths within the site not explored during our field program. Support of floor slabs on or above existing fill soils is discussed in this report. Based on the Standard Penetration Test (SPT) values and the moisture content test data, it appears that the fill was placed with at least some compactive effort. However, we have not been provided documentation to support this assumption. Therefore, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report.

Provided the owner is willing to accept the risks associated with supporting floor slabs over the existing fill materials in exchange for reduced construction costs, portions of the existing undocumented fill could be left in place for support of floor slabs. If this alternative is chosen, the existing fill should be proof-rolled to aid in delineating areas of soft or otherwise unsuitable material. Once unsuitable materials have been remediated, and the subgrade has passed the proof-roll test, any existing undocumented fill that was removed can be evaluated for reuse as structural fill under the floor slab area. If the owner is not willing to accept the risks of supporting floor slabs over existing undocumented fill materials, the existing fill should be completely removed and replaced.

Once initial stripping has been completed, the exposed subgrade soils should be proof-rolled with an adequately loaded vehicle, such as a fully loaded tandem axle dump truck with a gross weight of at least 25 tons, or similar loaded equipment. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas that rut or excessively deflect under the proof-roll should be improved by scarifying and compaction, or by removal and replacement with an approved engineered fill as discussed in **Fill Material Types**. Excessively wet or dry material should either be removed or moisture conditioned and recompacted.

Fill Material Types

Engineered fill should meet the following material property requirements:

Soil Type ^{1, 2}	USCS Classification	Acceptable Location for Placement
Cohesive	CL ³ , CL-ML ³ (LL ≤ 45 and PI ≤ 20)	Below/Adjacent to floor slabs
Granular	GW, GP, GM, GC, SW, SP, SM, SC 5% to 15% passing #200 sieve	Below/Adjacent to footings and floor slabs
Unsuitable	CH ⁴ , MH ⁴ , OL OH ⁴ , PT	Non-structural locations such as landscape areas General fill can include structural fill as well

1. Engineered fill soils should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. Any organic material, rock fragments larger than 3 inches, and other unsuitable material should be removed prior to use of these soils as fill.
3. Highly susceptible to frost, unstable when wet, are commonly used for pavement support with the knowledge that additional maintenance and/or shorter pavement life are likely.
4. High plasticity CH, MH, or OH soils should not be used beneath or adjacent to movement sensitive structures such as foundations, floor slabs, and pavements.

Fill Compaction Requirements

Engineered fill should meet the following compaction requirements.

Item	Description
Maximum Lift Thickness	9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum Compaction Requirements ^{1, 2, 3}	95% of the modified Proctor (ASTM D1557) maximum dry density below foundations and floor slabs. The compaction effort should extend laterally beyond the edges of the structures at least 8 inches for every foot of fill below the structure's elevation. 90% of the modified Proctor (ASTM D1557) maximum dry density in landscape areas.
Water Content Range ¹	Cohesive: -2% to +3% of the modified Proctor optimum moisture content (ASTM D1557) at the time of placement and compaction. Granular: As required to achieve minimum compaction requirements.

-
1. We recommend that engineered fill soils be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
 2. If the granular material is a coarse sand or gravel, is of uniform size, or has a low fines content, compaction comparison to relative density (ASTM D4253 and D4254) may be more appropriate. In this case, granular material should be compacted to at least 60% and 65% of the maximum relative density for the 90% and 95% modified Proctor recommendations, respectively.
 3. Moisture levels should be maintained to achieve compaction without bulking during placement or pumping when proof-rolled.
-

Grading and Drainage

The site should be graded to provide effective drainage away from the building during and after construction, and proper grades should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After construction and landscaping, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary as part of the site's maintenance program. Where paving or flatwork abuts the building a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to floor slab construction.

Based on the groundwater conditions observed during our field program and the predominantly clay soils encountered at this site, groundwater is not expected to be a major concern during construction of the proposed structure. However, if water seepage is encountered, the contractor should be prepared to remove water from the excavations. Water should not be allowed to accumulate in the bottom of the excavations. Water seepage that may occur can likely be managed by sump pits and pumps.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during foundation and underground fuel tank construction operations. The contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the observation of the Geotechnical Engineer or their representative. Monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency stated in **Earthwork**.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

To reduce the potential of unpredictable foundation performance and larger than expected settlements, footings excavations within the existing fill areas should extend through the existing gravel, sand, and lean clay fill and expose the undisturbed native lean clays below. The footings could then be constructed at this lower elevation on the native clays or the over excavations could

be backfilled with structural fill or lean concrete to the design footing elevation. In areas outside of the existing fill, native very stiff clay soils are likely to be encountered at the proposed footing elevation. In areas outside of the existing fill, very stiff native clay soils are likely to be encountered at proposed footing elevation. These soils are also suitable for support of shallow foundations. If unsuitable materials are encountered at the bottom of the footing excavations, the excavations should be extended deeper to reach suitable bearing materials.

The following design parameters are applicable for shallow foundations at this site.

Design Parameters – Compressive Loads

Item	Description
Suitable Bearing Materials	Native clays or structural fill/lean concrete that extends to the native clays
Maximum Net Allowable Bearing Pressure ¹	3,000 psf
Minimum Embedment Depth Below Finished Grade for Frost Protection ²	4 feet
Estimated Total Settlement from Structural Loads ³	About 1 inch
Estimated Differential Settlement ³	About ½ to ⅔ of total settlement
Minimum Foundation Dimensions	Isolated spread footings: 30 inches Continuous footings: 18 inches

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This pressure assumes that any soft/weak soils or unsuitable materials, if encountered, will be undercut and replaced with properly placed and compacted structural fill or lean concrete. This pressure also assumes that the foundation excavations extend through the overlying existing fill to the native undisturbed clays.
2. Foundation settlements will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of structural fill, and the quality of the earthwork operations and footings construction.

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils. The maximum allowable uplift capacity should be taken as a sum of the effective weight of soil plus the dead weight of the foundation, divided by an appropriate factor of safety. A maximum total unit weight of 110 pcf should be used for the backfill.

Construction Adjacent to Existing Building

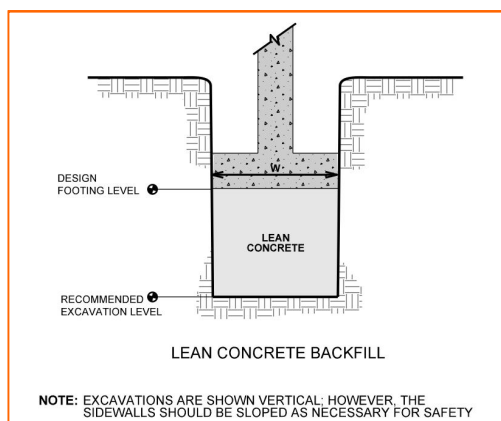
Differential settlement between the building addition and the existing building could approach the magnitude of the total settlement of the building addition. Care should be taken during excavation adjacent to existing foundations and grade beams to avoid disturbing existing soils.

Depending upon the locations and current loads on the existing footings, footings for the new building addition could cause settlement of adjacent walls. To reduce this concern and risk, clear distances at least equal to the new footing widths should be maintained between the new building addition footings and the foundations supporting the existing building. New footings should be placed at the level of existing footings so that existing footings are not undermined, or new load is not applied to existing foundation walls if the existing structure has a basement.

Foundation Construction Considerations

The base of all foundation excavations should be free of water and loose/soft soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level, or on structural fill or lean concrete backfill placed in the excavations. This is illustrated on the sketches below. If lean concrete backfill (minimum 28-day compressive strength of 1,500 psi) is used, widening of the footing excavation may not be needed.

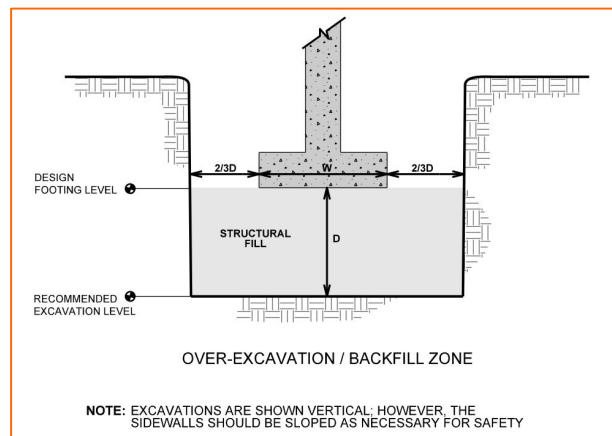


Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with structural fill placed, as recommended in the **Earthwork** section.

Geotechnical Engineering Report

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178



FLOOR SLABS

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support ¹	Minimum 5 inches of free-draining (less than 3% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95% of the modified Proctor (ASTM D1557) maximum dry density.
Estimated Modulus of Subgrade Reaction ²	125 pounds per square inch per inch (psi/in) for point loads.

1. Floor slabs should be structurally independent of footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.

2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should

be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Settlement of floor slabs supported on existing fill materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures as noted in **Site Preparation** within **Earthwork** are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams and/or post-tensioned elements.

Floor Slab Construction Considerations

Finished subgrade within and for at least 10 feet beyond the floor slab should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-10.

Description	Value
2015/2015 International Building Code Site Classification (IBC) ¹	D ²
Site Latitude	41.88085° N

Geotechnical Engineering Report

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178



Description	Value
Site Longitude	87.74120° W
S_{DS} Spectral Acceleration for a Short Period ³	0.147 g
S_{D1} Spectral Acceleration for a 1-Second Period ³	0.100 g

1. Seismic site classification in general accordance with the 2012/2015 *International Building Code*, which refers to ASCE 7-10.
2. The 2012/2015 *International Building Code* (IBC) uses a site profile extending to a depth of 100 feet for seismic site classification. Borings at this site were extended to a maximum depth of 20 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.
3. These values were obtained using online seismic design maps and tools provided by the USGS (<http://earthquake.usgs.gov/hazards/designmaps/>).

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Geotechnical Engineering Report

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178



Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
2	25	Building area

Boring Layout and Elevations: The borings were located using field measurements from existing site features. GPS coordinates and surface elevations for the boring locations shown on the boring logs were approximated from Google Earth.

Subsurface Exploration Procedures: We advanced the borings with an ATV-mounted rotary drill rig using hollow stem continuous flight augers. Six samples were obtained in the upper 15 feet of each boring and at 5-foot intervals thereafter. Soil sampling was performed using split-barrel sampling procedure. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and upon completion of drilling. For safety purposes, all borings were backfilled with auger cuttings and bentonite chips after their completion.

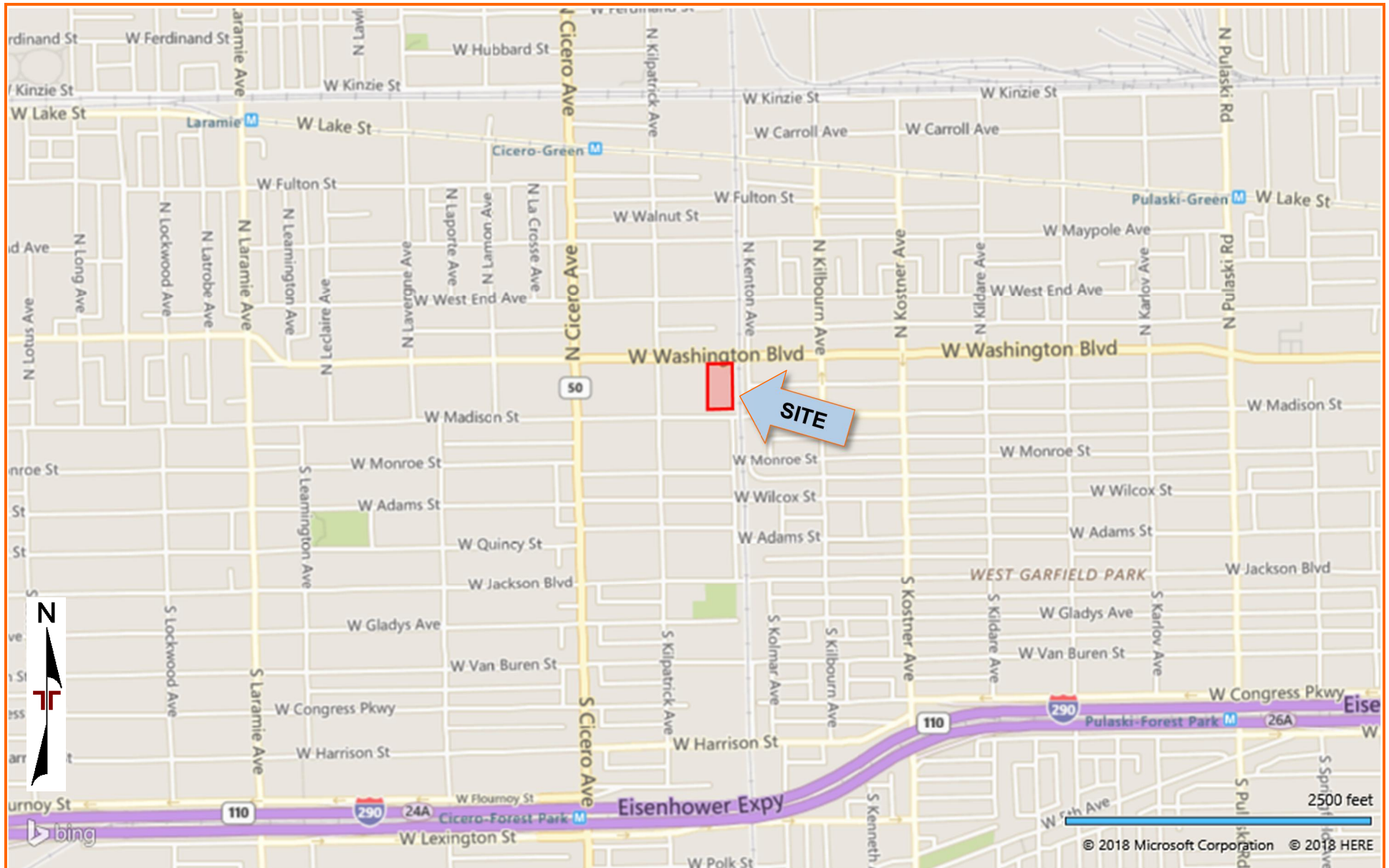
The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs include visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to better understand the engineering properties of the soil strata encountered in the borings. The laboratory program included moisture content testing of all samples and soil strength determination of cohesive soils using a hand penetrometer. The laboratory testing program also included examination of soil samples by the project engineer. Based on the texture and plasticity, we described and classified the soil samples in general accordance with the Unified Soil Classification System (USCS).

SITE LOCATION AND EXPLORATION PLANS

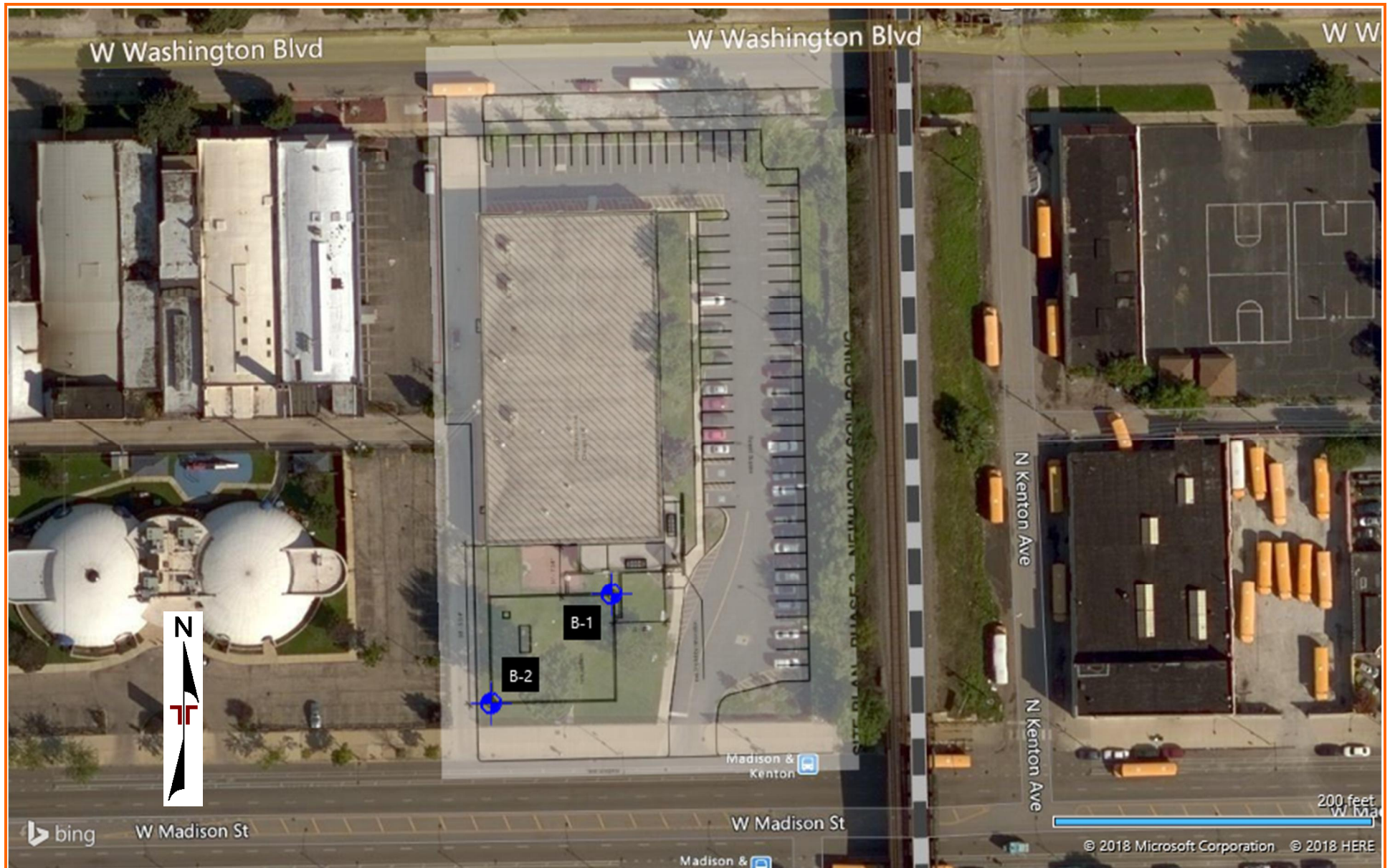
Westside Learning Center Building Addition ■ Chicago, Illinois
November 15, 2018 ■ Terracon Project No. MR185178



MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Westside Learning Center Building Addition ■ Chicago, Illinois
November 15, 2018 ■ Terracon Project No. MR185178



EXPLORATION RESULTS

(Boring Logs)

Page 1 of 1

CLIENT: Bailey Edward Design
Chicago, Illinois

SITE: 4642 Madison Avenue
Chicago, Illinois

GRAPHIC LOG	LOCATION See Exploration Plan	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	SAMPLE NUMBER	LABORATORY HP (tsf)	WATER CONTENT (%)
	Latitude: 41.8809° Longitude: -87.741° Approximate Surface Elev: 607 (Ft.) +/- ELEVATION (Ft.)								
	0.4 TOPSOIL , about 5 inches of topsoil FILL - MIX of GRAVEL AND SAND	606.5+/-		X	8	7-14-9 N=23	1		9
	3.0 FILL - LEAN CLAY (CL) , brown, with gravel	604+/-		X	6	4-7-7 N=14	2	2.50 (HP)	19
	6.0 LEAN CLAY (CL) , gray, very stiff to hard, with traces of sand and gravel	601+/-		X	14	2-4-8 N=12	3	3.50 (HP)	18
				X	14	6-9-7 N=16	4	4.50 (HP)	14
				X	16	4-5-7 N=12	5	3.50 (HP)	19
				X	14	4-6-7 N=13	6	5.00 (HP)	16
				X	14	7-7-8 N=15	7	5.25 (HP)	11
				X	12	8-9-11 N=20	8	4.00 (HP)	19
	Boring Terminated at 25 Feet	582+/-	25						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" hollow stem augers

See **Exploration and Testing Procedures** for a description of field and laboratory procedures used and additional data (If any).

Notes:

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See **Supporting Information** for explanation of symbols and abbreviations.

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
650 W Lake St, Ste 420
Chicago, IL

Boring Started: 11-01-2018

Boring Completed: 11-01-2018

Drill Rig: D-50

Driller: GEOCON/Nick

Project No.: MR185178


BORING LOG NO. B-2

Page 1 of 1

PROJECT: Westside Learning Center Building Addition

CLIENT: Bailey Edward Design
Chicago, Illinois

SITE: 4642 Madison Avenue
Chicago, Illinois

GRAPHIC LOG	LOCATION See Exploration Plan		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	SAMPLE NUMBER	LABORATORY HP (tsf)	WATER CONTENT (%)
	Latitude: 41.8808° Longitude: -87.7413°									
	Approximate Surface Elev: 604 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.8	TOPSOIL , about 10 inches of topsoil	603+/-							
		LEAN CLAY (CL) , brown and gray, very stiff, with traces of sand and gravel			X	10	2-5-6 N=11	1	3.00 (HP)	23
					X	10	2-3-4 N=7	2	3.00 (HP)	21
	6.0	SILTY CLAY WITH SAND (CL) , brown and gray, very stiff, with gravel	598+/-		X	14	4-10-10 N=20	3		12
					X	16	4-8-8 N=16	4	3.00 (HP)	18
					X	16	3-6-7 N=13	5	2.50 (HP)	18
					X	14	3-6-7 N=13	6	3.00 (HP)	16
	8.5	LEAN CLAY (CL) , gray, very stiff to hard, with traces of sand and gravel	595.5+/-		X	16	5-5-7 N=12	7	4.50 (HP)	14
					X	12	6-10-14 N=24	8	4.75 (HP)	18
	25.0	Boring Terminated at 25 Feet	579+/-							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 1/4" hollow stem augers

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

Notes:

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

WATER LEVEL OBSERVATIONS

19 ft While drilling

Terracon
650 W Lake St, Ste 420
Chicago, IL

Boring Started: 11-01-2018

Boring Completed: 11-01-2018

Drill Rig: D-50

Driller: GEOCON/Nick

Project No.: MR185178

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL MR185178 SINGLE-STORY BUILDING TERRACON DATATEMPLATE.GDT 11/16/18

SUPPORTING INFORMATION





(General Notes)
(Unified Soil Classification System)

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

West Side Learning Center Building ■ Chicago, Illinois

November 16, 2018 ■ Terracon Project No. MR185178

SAMPLING	WATER LEVEL	FIELD TESTS
 Split Spoon	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time <p>Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.</p>	<p>(N) Standard Penetration Test Resistance (Blows/Ft.)</p> <p>(HP) Hand Penetrometer</p> <p>(T) Torvane</p> <p>(DCP) Dynamic Cone Penetrometer</p> <p>(UC) Unconfined Compressive Strength</p> <p>(PID) Photo-Ionization Detector</p> <p>(OVA) Organic Vapor Analyzer</p>

DESCRIPTIVE SOIL CLASSIFICATION
<p>Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.</p>
LOCATION AND ELEVATION NOTES
<p>Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.</p>

STRENGTH TERMS				
RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (tsf)	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12
GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	Particle Size	Term	Plasticity Index
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm)	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

UNIFIED SOIL CLASSIFICATION SYSTEM

Westside Learning Center Building Addition ■ Chicago, Illinois

November 15, 2018 ■ Terracon Project No. MR185178

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A					Soil Classification	
					Group Symbol	Group Name ^B
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines ^C	Cu ³ 4 and 1 £ Cc £ 3 ^E		GW	Well-graded gravel ^F
			Cu < 4 and/or 1 > Cc > 3 ^E		GP	Poorly graded gravel ^F
		Gravels with Fines: More than 12% fines ^C	Fines classify as ML or MH		GM	Silty gravel ^{F, G, H}
			Fines classify as CL or CH		GC	Clayey gravel ^{F, G, H}
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines ^D	Cu ³ 6 and 1 £ Cc £ 3 ^E		SW	Well-graded sand ^I
			Cu < 6 and/or 1 > Cc > 3 ^E		SP	Poorly graded sand ^I
		Sands with Fines: More than 12% fines ^D	Fines classify as ML or MH		SM	Silty sand ^{G, H, I}
			Fines classify as CL or CH		SC	Clayey sand ^{G, H, I}
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	PI > 7 and plots on or above “A”		CL	Lean clay ^{K, L, M}
			PI < 4 or plots below “A” line ^J		ML	Silt ^{K, L, M}
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay ^{K, L, M, N}
			Liquid limit - not dried			Organic silt ^{K, L, M, O}
	Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots on or above “A” line		CH	Fat clay ^{K, L, M}
			PI plots below “A” line		MH	Elastic Silt ^{K, L, M}
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay ^{K, L, M, P}
			Liquid limit - not dried			Organic silt ^{K, L, M, Q}
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

^A Based on the material passing the 3-inch (75-mm) sieve

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

^D Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

$$E \quad Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains ³ 15% sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains ³ 15% gravel, add "with gravel" to group name.

^J If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^L If soil contains ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

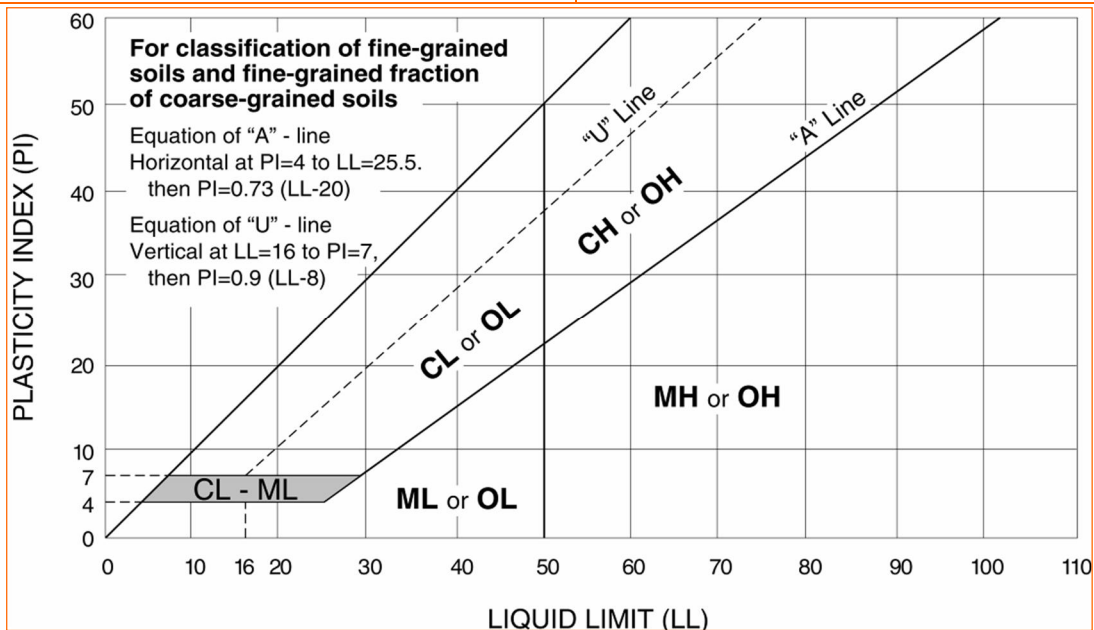
^M If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

^N PI ³ 4 and plots on or above "A" line.

^O PI < 4 or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.





33 W. Monroe St., Suite 1825
Chicago, IL 60603
phone: 312.345.1400
fax: 312.345.0529
www.envdesigni.com

February 27, 2018

Ms. Ellen Dickson, FAIA, ALA, LEED, AP,
NCARB, NCIDQ
Principal
Bailey Edward (BE)
35 East Wacker Drive, Suite 2800
Chicago, IL 60601

**Subject: Report for Environmental Hazards Material Assessment (HMA)
508/District Wide: Malcolm X College – West Side Learning Center
BNA Classroom and Two Biology Lab Addition
Malcolm X College
4624 West Madison Street
Chicago, IL 60644**

Dear Ms. Dickson:

Enclosed please find the environmental review report for the above identified property, prepared by Environmental Design International inc. (EDI).

EDI performed the HMA to identify and report suspect asbestos-containing materials (ACM) or lead-based paint (LBP) associated with the planned renovation project at the Malcolm X College – West Side Learning Center project located in Chicago, Illinois. Please refer to the attached report for details on the limited environmental review.

Please feel free to contact Ray Cienas at (312) 345-0469, rcienas@envdesigni.com or Gary Flentge at (312) 345-8679, gflentge@envdesigni.com with any comments or questions regarding EDI's investigation and this report.

Sincerely,

Environmental Design International inc.

A handwritten signature in blue ink that reads 'Raymond A. Cienas'.

Raymond Cienas
Project Manager

A handwritten signature in blue ink that reads 'Gary P. Flentge'.

Gary P. Flentge, MPH, LEHP, REPA, CESCO
Vice President, Industrial Hygiene
Principal Environmental Health Professional

Executive Summary	1
1.0 Introduction.....	4
1.1 Project Purpose and Background.....	4
1.2 Scope of Work	4
2.0 Limited Asbestos Survey	6
2.1 Limited Asbestos Survey Methodology	6
2.2 Limited Asbestos Survey Results	7
2.3 Applicable Regulations.....	9
3.0 Limited LBP Survey	11
3.1 Limited LBP Survey Methodology	11
3.2 Limited LBP Survey Results	11
3.3 Applicable Regulations and Guidelines	11
4.0 HAZMAT Survey.....	13
4.1 HAZMAT Survey Methodology.....	13
4.2 HAZMAT Survey Results	13
5.0 Findings and Recommendations	15
5.1 Asbestos Building Survey	15
5.2 LBP Building Survey	16
5.3 HAZMAT Building Survey	16
6.0 Limitations	17
7.0 References & Definitions	18

Appendices

Appendix A:	Table I - Asbestos Survey Analytical Summary
Appendix B:	Asbestos Laboratory Results, Laboratory Certifications and Chain-of-Custodies
Appendix C:	Lead Survey
Appendix D:	EDI Employee Certification
Appendix E:	Previous Environmental Reports

Executive Summary

Environmental Design International inc. (EDI) was retained by Bailey Edward (BE) to provide a limited HMA including assessment and sampling for ACM, LBP, and a visual HAZMAT survey of the project renovation space as defined by the work order provided by BE. The project space is inclusive of the Malcolm X College – West Side Learning Center of the building located at 4624 West Madison Street, Chicago, IL.

The limited HMA was performed on February 8 and February 9, 2018, by Mr. Jarrett Land, Illinois Department of Public Health (IDPH) licensed asbestos inspector (asbestos license #100-11233). The HMA was conducted for the planned renovations within the defined project areas.

EDI reviewed the historical environmental report “Asbestos Survey” dated December 1990 by Certified Engineering and Testing Company, Inc. EDI performed a visual survey of building materials, and collected representative samples of homogeneous suspect ACM, in accordance with EPA requirements, guidelines and standard industry practices. The samples were submitted to a National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory for bulk analysis. Painted components were tested for presence of LBP using an x-ray fluorescence (XRF) spectrum analyzer. Other potentially hazardous or universal waste materials (HAZMAT) were identified by visual assessment.

ACM Results

Based on the bulk sample by EDI and laboratory analysis, the following suspect materials were reported to contain asbestos:

Material Description	Material Quantity	Material Location	Laboratory Results
12” x 12” Tan Floor Tile Black Mastic	~ 22,000 SF	Ground Floor, Room 116, 121, 105, North Hall, Basement Lunchroom, B4, B5, Classrooms	PC 2.1% Chrysotile
12” x 12” White Floor Tile Black Mastic	~ 5,000 SF	Ground Floor, Room 102, 131, 132	PC 3.2% Chrysotile
Off White Textured Plaster	~ 37,000 SF	Throughout Facility	PC 7.3% Chrysotile
Black/Tan Red Carpet Adhesive	~ 3,000 SF	Ground Floor, Room 125, 130	PC 3.3% Chrysotile

PC = point count

Based on the report provided to EDI entitled, “Asbestos Survey” dated December 1990 by Certified Engineering and Testing, Inc., the following suspect materials were reported to contain asbestos:

Material Description	Material Quantity	Material Location	Laboratory Results
Textured Plaster	~ 35,000	Throughout	5%-10% Asbestos

EDI recommends that these materials be abated, removed and disposed of as ACM if they will be impacted by the planned renovations. Abatement should be designed by a State-licensed asbestos project designer and comply with applicable federal, state and local regulations.

LBP Results

None of the building materials were that were sampled were reported to contain LBP.

HAZMAT Results

EDI identified a variety of materials and products during the completion of the HAZMAT survey.

Material Description	Estimated Quantity
Fluorescent Light Bulbs/ballasts	880/440
Fire Signal	7
Fire Extinguisher	8
Exit Signs	12
Thermostat	Present
Water Fountains	2
Black Spray Paint	4
10w40 Motor Oil	2
Turf Builder	4 (2-gallon bags)
Glass Cleaner	2 Gallons
Raid Roach Spray	5 (20oz Cans)
Fire Doors	5
Bathroom Cleaner	2.5qt (x2)
Bleach	1 Gallon
Potential Silica-based hazards	Present
Suspect microbial growths	Not Present
CFC's	Not present

Suspect hazardous materials should be removed, handled, and disposed of in accordance with applicable federal, state, and local regulations if they will be impacted by planned renovations.

1.0 Introduction

EDI was retained by BE to provide a limited HMA including assessment and sampling for ACM, LBP, and a visual HAZMAT Survey of the project renovation space as defined by the work order provided by BE. The project space is inclusive of the Malcolm X College – West Side Learning Center of the building located at 4624 West Madison Street, Chicago, IL. The environmental evaluation was performed on February 8 and February 9, 2018 by Mr. Jarrett Land, Illinois Department of Public Health (IDPH) licensed asbestos inspector (Asbestos License #100-11233).

1.1 Project Purpose and Background

The limited HMA was performed prior to the planned renovations of the select areas of the Malcolm X College – West Side Learning Center.

1.2 Scope of Work

EDI evaluated the facility for the presence of hazardous materials. Following items were included in the scope of work.

Limited Asbestos Verification and Quantification Inspection

EDI performed a survey to determine and quantify suspect ACM within the renovation space within facility as defined by BE. The entire building was NOT included in the survey. The ACM survey included the following activities:

- Review of historical ACM survey report;
- Visual inspection of accessible areas of the subject property;
- Collection of bulk samples of identified suspect ACM per homogeneous materials;
- NVLAP accredited laboratory analysis of suspect ACM bulk samples by polarized light microscopy (PLM) to first positive result per homogeneous material; and,
- Preparation of a final report of findings.

Limited LBP Survey

EDI performed a limited LBP survey, including review of historical environmental reports and testing of select surfaces that may be impacted by project activities. EDI utilized XRF technology for testing selected surfaces throughout the proposed renovation area. EDI's LBP survey utilized modified procedures and XRF testing consistent with the U.S. Environmental Protection Agency (USEPA) regulations and guidelines. LBP testing by XRF is a non-destructive testing protocol and no paint chip sampling or lead dust wipe were included in the survey. Representative sampling areas (RSAs), consisting of similar components with similar paint color and application, were defined and tested.

Limited HAZMAT Survey

EDI – EXCELLENCE, DEDICATION & INNOVATION

(312) 345-1400 • WWW.ENVDESIGNI.COM



EDI performed a limited visual hazardous and non-hazardous material survey only in the areas that are planned for the renovation activities. HAZMAT surveys were performed by EDI's experienced and trained professionals. At a minimum, inspectors performing the hazardous material surveys have completed the OSHA Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) initial and subsequent refresher training courses. The hazardous material surveys focused on identifying potentially hazardous materials such as polychlorinated biphenyl (PCB)-containing components, mercury-containing components, chemicals and other hazardous and non-hazardous materials that will require special handling and disposal prior to demolition activities that may affect those materials. No physical sampling of any potentially hazardous materials was performed as part of the survey.

2.0 Limited Asbestos Survey

2.1 Limited Asbestos Survey Methodology

EDI performed a visual survey of building materials and collected representative samples of homogeneous suspect ACM, in accordance with EPA requirements, guidelines and standard industry practices. The representative sampling was performed using hand-tools without aid of power driven equipment. Based on the authorized scope of work, EDI was not required to repair damage from the representative sampling.

Only currently certified and licensed inspector(s) and (if appropriate) trainee(s) were utilized for this inspection.

The inspector(s) first reviewed supplied building documents, if applicable. A property/structure(s) walk-thru was then conducted to locate, identify, measure and separate identified suspect asbestos containing materials into homogeneous areas.

Samples were collected using EPA approved methods specifically designed for sample collection. Samples were taken utilizing the randomly distributive manner method while simultaneously applying amended water. Samples were immediately placed in a pre-labeled re-sealable plastic bag. To prevent accidental exposure, sample containers are made of a durable plastic designed to provide and airtight seal. The sampling instrument was subsequently wiped with a clean moist cloth to decontaminate the tool, prevent the potential release of asbestos fibers, and prevent cross contamination of subsequent samples. Sample areas were assessed to determine friability.

The following chart, as detailed by 40 CFR 763.86, is typically used (and in certain cases, required) for sampling surfacing materials that are spray-applied and troweled-on to walls and ceilings;

< 1000 s/f	3 samples
1000 – 5000 s/f	5 samples
>5000 s/f	7 samples
9 samples are recommended by the EPA for all samples	

A minimum of three (3) samples of other suspect homogeneous materials consisting of thermal systems insulation (TSI) on the mechanical systems;

A group letter or combination of letter and number was assigned to each homogenous material. This combination serves as a prefix to identify materials of similar composition, texture, color, and date of installation, i.e., ceiling tile may be represented as CT1. Each sample was then assigned a sample number such as 01, 02, 03, etc.

All samples were identified on a signed and dated Chain-of-Custody document, which accompanied the samples to the laboratory.

The bulk samples were submitted to a National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory for bulk analysis. To ensure both quality and objectivity, an independent laboratory was used. Laboratories are selected based on their current accreditations. The laboratory chosen participates in the National Voluntary Laboratory Accreditation Program (NVLAP) for quality control procedures (NVLAP Lab Code: 101202-0). As specified in 40 CFR Chapter I (1-1-87 edition) Part 763, Subpart F, Appendix A - Figure 1.

Suspected asbestos samples were analyzed using polarized light microscopy (PLM) / dispersion staining techniques in accordance with the EPA Method documents "US EPA 600/M4-82-020, 1982" & "US EPA 600/R-93/118, 1993". Detection limits for this type of analysis are approximately one percent (by volume). All samples were analyzed by International Asbestos Testing Laboratories of Mt. Laurel, New Jersey (IATL), a National Voluntary Laboratory Accreditation Program (NVLAP) accredited asbestos laboratory. Laboratory results and accreditations are provided in Appendix B.

It should be noted when reviewing the data that multiple results can be reported for the same sample number. This is due to the fact that particular types of samples can produce multiple layers to be analyzed (i.e., floor tile and mastic, drywall and drywall compound, multi-layered TSI). However, while the laboratory will separate the different layers of the material for analysis, during the renovation if one layer of a multi-layered material is positive for asbestos, then all layers of that positive sample are considered positive for asbestos.

Some materials may not be accurately identified and/or quantified by PLM. As an example, the original fabrication of vinyl floor tile routinely involved milling of asbestos fibers to extremely small sizes. As a result, these fibers may go undetected under the standard PLM method. Transmission Electron Microscopy (TEM) is required for a more definitive analysis of these materials. These types of flooring materials that are reported by laboratory analysis to be non-asbestos by PLM analysis are routinely submitted to an accredited laboratory for analysis under TEM for verification of asbestos content. No samples were tested with TEM analysis for this project.

2.2 Limited Asbestos Survey Results

SUSPECT ASBESTOS CONTAINING MATERIALS

The following suspect asbestos containing materials were identified and sampled by EDI:

4624 West Madison Street Malcolm X College – West Side Learning Center Chicago, IL		
12" x 12" Tan Floor Tile and Black Mastic	Brown Baseboard and Adhesive	Black Baseboard and Adhesive

4624 West Madison Street Malcolm X College – West Side Learning Center Chicago, IL		
Blue Baseboard and Adhesive	12" x 12" Black Floor Tile and Black Mastic	12" x 12" Red Floor Tile and Black Mastic
12" x 12" White Floor Tile and Black Mastic	2' x 4' Ceiling Tile	Drywall, Tape and Joint Compound
Textured Plaster	Window Glaze	Black/Tan Red Carpet Mastic

According to the AHERA Model Accreditation Plan, non-suspect material such as fiberglass, foam rubber and plastics do not warrant sampling.

SUSPECT MATERIALS REPORTED AS ACM

Based on the bulk sample by EDI and laboratory analysis, the following suspect materials were reported to contain asbestos:

Material Description	Material Quantity	Material Location	Laboratory Results
12" x 12" Tan Floor Tile Black Mastic	~ 22,000 SF	Ground Floor, Room 116, 121, 105, North Hall, Basement Lunchroom, B4, B5, Classrooms	PC 2.1% Chrysotile
12" x 12" White Floor Tile Black Mastic	~ 5,000 SF	Ground Floor, Room 102, 131, 132	PC 3.2% Chrysotile
Off White Textured Plaster	~ 37,000 SF	Throughout Facility	PC 7.3% Chrysotile
Black/Tan Red Carpet Adhesive	~ 3,000 SF	Ground Floor, Room 125, 130	PC 3.3% Chrysotile

PC = point count

Based on the report provided to EDI entitled, “Asbestos Survey” dated December 1990 by Certified Engineering and Testing, Inc., the following suspect materials were reported to contain asbestos:

Material Description	Material Quantity	Material Location	Laboratory Results
Textured Plaster	~ 35,000	Throughout	5%-10% Asbestos

EDI recommends that these materials be abated, removed and disposed of as ACM if they will be impacted by the planned renovations. Abatement should be designed by a State-licensed asbestos project designer and comply with applicable federal, state and local regulations.

2.3 Applicable Regulations

Environmental Protection Agency (EPA)

EPA's National Emission Standard for Hazardous Air Pollutants (NESHAP) (40 CFR 61, Subpart M) categorizes asbestos-containing materials (ACM) as any product that contains >1% asbestos, thereby ACM is regulated by EPA. EPA classifies the >1% asbestos materials as Regulated ACM, (RACM). Materials that contain <1% asbestos are not ACM; they are not regulated by EPA; and, are thereby not RACM.

Thermal system insulation (TSI) and sprayed-on or troweled-on asbestos is friable Regulated ACM (RACM); miscellaneous materials (floor tile and floor tile mastic) are classified as Category I Non-Friable Asbestos; and transite material is classified as Category II Non-Friable Asbestos, unless the material is made friable during demolition. Friable ACM is material that can be crumbled, pulverized, or reduced to a powder by hand.

NESHAP requires at least ten working days' notification prior to any renovation or demolition activity that will disturb greater than 160 square feet or 260 linear feet of RACM materials. RACM removed during abatement must be disposed of at a landfill approved by the EPA to receive asbestos wastes.

NESHAP states that RACM, including friable ACM and non-friable ACM that has become or has a high probability of becoming friable, present in quantities exceeding 260 lineal feet on pipes or 160 square feet on facility components must be removed prior to the commencement of any demolition activities. NESHAP also states that Category 1 non-friable ACM does not need to be removed prior to demolition if it is not in poor condition and has not become friable. Friable materials (with the exception of roofing products) and transite are typically required to be removed prior to a demolition. Asbestos containing floor tile and mastic are required to be removed from concrete prior to recycling. If a facility is demolished by intentional burning, all regulated asbestos containing materials including Category I and Category II non-friable ACM must be removed before burning.

Illinois Department of Public Health (IDPH)

IDPH requires that a licensed abatement contractor perform the removal of ACM from the interior of facilities located within the State of Illinois. In addition, personnel performing the asbestos removal must be Illinois-licensed workers overseen by an Illinois-licensed supervisor. An Illinois-licensed Asbestos Project Designer should design the abatement of ACM, although no design is required under NESHAP regulations.

Occupational Safety and Health Administration (OSHA)

The Occupational Safety and Health Administration (OSHA) Construction Industry Standard (29 CFR) regulated materials that contain asbestos. Unlike EPA regulations, OSHA regulations **DO APPLY** to materials <1% asbestos. OSHA regulations specify minimum work practice standards and engineering controls for materials that contain <1% asbestos. OSHA regulations also specify more stringent engineering controls and work practices for employees handling ACM (>1% asbestos).

OSHA categorizes the removal of ACM, as defined by EPA, by “class” of material. Specific requirements for the removal of OSHA classified materials include, but are not limited to, regulated work areas, air monitoring, engineering controls, work practices, personal protective equipment, notification and training.

U.S. Department of Transportation (DOT)

The U.S. Department of Transportation (DOT) requires special procedures for packaging, labeling and transportation of asbestos wastes to disposal facilities. Other regulations may apply depending upon the contractor's means and methods.

3.0 Limited LBP Survey

3.1 Limited LBP Survey Methodology

EDI staff performed a limited visual survey of the building to identify representative painted surfaces for LBP testing. The limited LBP survey was conducted following a modified and limited sampling plan based on the USEPA regulations and guidelines. XRF and paint chip collection was used for this survey.

EDI utilized XRF technology in the form of a Thermo-Scientific Niton, Model XLp, which utilizes a Cadmium-109 source, for testing selected surfaces/components throughout the proposed renovation area. LBP testing by XRF is a non-destructive testing protocol and no paint chip sampling or lead dust wipe sampling was included in the survey. RSAs, consisting of similar components with similar paint color and application based on the age and era of construction, were defined and tested. The limited LBP survey was focused to determine surfaces/components that may require special handling for recycling and disposal as part of the planned renovation/demolition. The XRF is a Niton Lead Paint Analyzer (LPA) 1 using a Cobalt-57 (Co-57) isotope with a 20 milli-curie source. The XRF analyzer was used on interior and exterior painted surfaces that were determined to be Representative Sampling Areas (RSAs). RSAs are materials that are similar in color, texture, and general appearance, and which appear to have been painted during the same time period. Calibration checks of the XRF analyzer were performed prior to and at the conclusion of the shift. The XRF analyzer provides immediate positive or negative result readings of the painted surface, which are then recorded on a lead sample log.

3.2 Limited LBP Survey Results

None of the building materials that were sampled were reported to contain LBP.

3.3 Applicable Regulations and Guidelines

U.S. Department of Housing and Urban Development (HUD)

Although not applicable to public and commercial properties, HUD guidelines cover topics such as lead-based paint inspections/risk assessments, abatement options and methods, worker protection, occupant protection, cleanup, clearance, and waste. Except for those parts pertaining exclusively to housing, the guidelines can be used as resource information and methodologies for identifying and abating lead-based paint hazards in buildings.

Environmental Protection Agency (EPA)

EPA regulations and guidelines cover requirements for certification and testing for LBP in residential structures. Work practices include topics such as: lead-based paint inspections/risk assessments; abatement options and methods; cleanup; clearance; and, waste disposal.

According to the Illinois Resource Conservation and Recovery Act (35 IAC 721), and IEPAs *Information Statement on the Removal of Lead-Based Paint*, workers handling LBP coated building materials must be protected from exposure following OSHA regulations.

Illinois Department of Public Health (IDPH)

Although not applicable to public and commercial properties, Illinois Administrative Code 845 (Title 77, Chapter I, and Subchapter P, Part 845) defines lead abatement/mitigation as the remediation of a lead hazard so that the lead bearing substance does not pose an immediate health hazard to humans. Except for those parts pertaining exclusively to housing, the regulations can be used as resource information and methodologies for identifying and abating lead-based paint hazards in Illinois.

U.S. Department of Transportation (DOT)

USDOT and IDOT require lead-based paint waste to be properly containerized and transported by a licensed waste hauler.

4.0 HAZMAT Survey

4.1 HAZMAT Survey Methodology

HAZMAT material surveys were performed by EDI's experienced and trained professionals. At a minimum, inspectors performing the hazardous material surveys have completed the OSHA HAZWOPER initial and subsequent refresher training courses. The hazardous material surveys focused on identifying potentially hazardous materials such as: polychlorinated biphenyl (PCB)-containing components; mercury-containing components; chemicals; potential microbial growths; potential silica-based components; and, other hazardous and non-hazardous materials that will require special handling and disposal prior to demolition activities that may affect those materials.

No physical sampling of any potentially hazardous materials was performed as part of the survey.

EDI performed a visual survey for suspect hazardous materials that are regulated under the United States Environmental Protection Agency (USEPA) Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control Act (TSCA) regulations for hazardous waste management in the areas planned for demolition. Suspect hazardous materials were identified, quantified, recorded on a field log, and photographed. The suspect hazardous materials were not sampled, therefore these materials should be presumed to be hazardous until sampling confirms otherwise.

4.2 HAZMAT Survey Results

Refer to Table 3 below for a detailed listing of the identified suspect hazardous materials.

Table 3

Material Description	Estimated Quantity
Fluorescent Light Bulbs/ballasts	880/440
Fire Signal	7
Fire Extinguisher	8
Exit Signs	12
Thermostat	Present
Water Fountains	2
Black Spray Paint	4
10w40 Motor Oil	2
Turf Builder	4 (2-gallon bags)
Glass Cleaner	2 Gallons
Raid Roach Spray	5 (20oz Cans)
Fire Doors	5
Bathroom Cleaner	2.5qt (x2)

Bleach	1 Gallon
Potential Silica-based hazards	Present
Suspect microbial growths	Not Present
CFC's	Not present

The suspect hazardous materials were not sampled; therefore, these materials should be presumed to be hazardous until sampling confirms otherwise.

5.0 Findings and Recommendations

The following is a summary of the findings and recommendations based on the limited environmental evaluation for base design services. Once the final design is complete, EDI will need to complete the pre-alteration inspection as required by GSA policy.

5.1 Asbestos Building Survey

Based on the bulk sample by EDI and laboratory analysis, the following suspect materials were reported to contain asbestos:

Material Description	Material Quantity	Material Location	Laboratory Results
12" x 12" Tan Floor Tile Black Mastic	~ 22,000 SF	Ground Floor, Room 116, 121, 105, North Hall, Basement Lunchroom, B4, B5, Classrooms	PC 2.1% Chrysotile
12" x 12" White Floor Tile Black Mastic	~ 5,000 SF	Ground Floor, Room 102, 131, 132	PC 3.2% Chrysotile
Off White Textured Plaster	~ 37,000 SF	Throughout Facility	PC 7.3% Chrysotile
Black/Tan Red Carpet Adhesive	~ 3,000 SF	Ground Floor, Room 125, 130	PC 3.3% Chrysotile

PC = point count

Based on the report provided to EDI entitled, "Asbestos Survey" dated December 1990 by Certified Engineering and Testing, Inc., the following suspect materials were reported to contain asbestos:

Material Description	Material Quantity	Material Location	Laboratory Results
Textured Plaster	~ 35,000	Throughout	5%-10% Asbestos

EDI recommends that these materials be abated, removed and disposed of as ACM if they will be impacted by the planned renovations. Abatement should be designed by a State-licensed asbestos project designer and comply with applicable federal, state and local regulations.

5.2 LBP Building Survey

None of the building materials were that were sampled were reported to contain LBP.

5.3 HAZMAT Building Survey

EDI identified a variety of materials and products during the completion of the HAZMAT survey. These materials should be removed and disposed of in accordance to applicable rules and regulations, if impacted by planned renovations.

Material Description	Estimated Quantity
Fluorescent Light Bulbs/ballasts	880/440
Fire Signal	7
Fire Extinguisher	8
Exit Signs	12
Thermostat	Present
Water Fountains	2
Black Spray Paint	4
10w40 Motor Oil	2
Turf Builder	4 (2-gallon bags)
Glass Cleaner	2 Gallons
Raid Roach Spray	5 (20oz Cans)
Fire Doors	5
Bathroom Cleaner	2.5qt (x2)
Bleach	1 Gallon
Potential Silica-based hazards	Present
Suspect microbial growths	Not Present
CFC's	Not present

Suspect hazardous materials should be removed, handled, and disposed of in accordance with applicable federal, state, and local regulations if they will be impacted by planned renovations.

6.0 Limitations

The conclusions of this report are EDI's professional opinions, based solely upon visual site observations and interpretations of laboratory analyses, as described in this report. The opinions presented herein apply to the site conditions existing at the time of EDI's investigation and interpretation of current regulations. Therefore, EDI's opinions and recommendations may not apply to future conditions that may exist at the site, which we have not had the opportunity to evaluate. It should be noted that conditions change and that materials constantly degrade. All applicable federal, state and local regulations should always be verified prior to any work that will disturb or dislodge materials confirmed, assumed or presumed to contain asbestos. The survey was conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the environmental profession under similar conditions. No other warranty or guarantee, express or implied, is included or intended in this Report or otherwise.

With exception to the suspect flooring system assessment and sampling, no selective destruction of interior finishes and surfaces was included in the scope of work for the subject property in order to access identifiable concealed spaces, utility chases, and enclosed areas.

EDI's assessment was limited to observations, sampling and the analysis of suspect asbestos containing products in accessible portions of the area(s) covered by this survey and based on the drawings provided for the work areas that will be impacted. Materials in the building that are not considered building materials, are unusual or *de minimis*, or were inaccessible, due to common construction techniques, to the inspector were excluded from the inspection. As a result, additional ACM, LBP or HAZMAT may be present in inaccessible areas (e.g. between walls, ceiling spaces enclosed by wallboard, interior of fire doors, etc.) of the structure that were not observed during the survey.

This inspection report is designed to assist the client in the understanding of the regulations regarding asbestos. However, it should not be used as a substitution for obtaining and familiarizing yourself with, including the compliance of, all federal, state, and local regulations prior to the start of any renovation or demolition activity.

This report has been prepared for the exclusive use of the intended client, for the specific application to the defined property as addressed in this report. Any additional user of this report shall determine the suitability of the material contained herein for their intended use, and any such user assumes all risks and liability in connection therewith. No claim is made that these findings will remain applicable to future site activities and conditions. Interpretations by any such user from information contained in this report or the drawing of conclusions by any such user from information contained in this report shall be undertaken solely at the risk of said party.

At all times during the performance of the inspection, safety was a priority. Due to the emphasis on safety, there were no injuries, and there were no exposures to either EDI personnel or building occupants.

7.0 References & Definitions

Illinois Department of Public Health (IDPH)

77 Illinois Administrative Code Part 855

Illinois Lead Regulations

77 Illinois Administrative Code 845

United States Environmental Protection Agency (USEPA)

Asbestos Hazard Emergency Response Act (AHERA), 40 CFR, Part 763

National Emission Standards for Hazardous Air Pollutants (NESHAP), Asbestos, 40 CFR, Part 61, November 20, 1990

Guidance for Controlling Asbestos-Containing Materials in Buildings (EPA 560/5-85/024), June 1985

EPA Lead Regulations

40 CFR Part 745

United States Occupational Safety and Health Administration (OSHA)

29 CFR, Parts 1910 and 1926

29 CFR 1926.62

DEFINITIONS

Asbestos-containing material or “ACM” means a material or product that contains more than 1% of asbestos, as determined using the method specified in 40 CFR Part 763, Appendix E to Subpart E, Section I, “Polarized Light Microscopy,” and a material meeting the definition of suspect asbestos-containing material.

Asbestos Containing Products means, according to the U.S. EPA Method 600/R-93/116, Regulated Asbestos Containing Materials (RACM) are those materials found to contain greater than 1% asbestos per volume of bulk material sampled, by PLM. The term is not intended to include *de minimis* or inaccessible materials that do not present a risk of harm to public health and that generally would not be the subject of enforcement actions if brought to the attentions of appropriated regulatory agencies.

Asbestos Types are Chrysotile (white asbestos making up approximately 95% of all asbestos

EDI – EXCELLENCE, DEDICATION & INNOVATION

(312) 345-1400 • WWW.ENVDIGNI.COM



used in the United States), Amosite (brown asbestos making up approximately 5% of all asbestos used in the United States), Crocidolite (blue asbestos making up approximately less than 5% of all asbestos used in the United States), and rarely found in buildings are Anthophyllite, Tremolite & Actinolite.

Category I Non-Friable Asbestos-Containing Material (ACM) means asbestos-containing packing, gaskets, resilient floor covering, and asphalt roofing products containing more than 1 percent asbestos as determined using the method specified in appendix E, subpart E, 40 CFR part 763, section 1, Polarized Light Microscopy.

Category II Non-friable ACM means any material, excluding Category I nonfriable ACM containing more than 1 percent asbestos as determined using the methods specified in appendix E, subpart E, 40 CFR part 763, section 1, Polarized Light Microscopy that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

Demolition means the wrecking or taking out of any load-supporting structural member of a facility together with any related handling operations or the intentional burning (i.e. practice burns) of any facility.

Facility means any institutional, commercial, public, industrial, or residential structure, installation, or building (including any structure, installation, or building containing condominiums or individual dwelling units operated as a residential cooperative, but excluding residential buildings having four or fewer dwelling units); any ship; and any active or inactive waste disposal site. For purposes of this definition, any building, structure, or installation that contains a loft used as a dwelling is not considered a residential structure, installation, or building. Any structure, installation, or building that was previously subject to the Asbestos NESHAP is not excluded, regardless of its current use or function.

Friable Asbestos Material means any material containing more than 1 percent asbestos as determined using the method specified in appendix E, subpart E, 40 CFR part 763 section 1, Polarized Light Microscopy, that, when dry, can be crumbled, pulverized, or reduced to powder by hand pressure.

Homogeneous Area means an area of surfacing materials, thermal surface insulation, or miscellaneous material that is uniform in color and texture and has the same installation date.

Lead-Based Paint

Paint or surface coatings that contain lead levels greater than or equal to 1.0 milligram per square centimeter, or more than 0.5% lead by weight.

Miscellaneous Material means interior building material on structural components, structural members or fixtures, such as floor and ceiling tiles, and does not include surfacing material or thermal system insulation.

Multi-layered Material means a material that has a presence of discrete individual layers. EPA does not regard a sheet of “plasterboard,” sheetrock,” “wallboard,” or “gypsum board” by itself a

multi-layered material.

Polarized Light Microscopy means an optical microscopy technique for analyzing bulk samples for asbestos in which the sample is illuminated with polarized light (light which vibrates in only one plane) to distinguish between different types of asbestos fibers by their shape and unique optical properties.

Presumed Asbestos Containing Material (PACM), as defined in 29 CFR 1910 & 1926, means thermal system insulation and surfacing material found in buildings constructed no later than 1980.

Regulated Asbestos-Containing Material (RACM), as defined in 40 CFR 61.141, means

- (a) Friable asbestos material,
- (b) Category I non-friable ACM that has become friable,
- (c) Category I non-friable ACM that will be or has been subjected to sanding, grinding, cutting, or abrading, or
- (d) Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected to act on the material in the course of demolition or renovation operations.

Renovation means altering a facility or one or more facility components in any way, including the stripping or removal of Regulated Asbestos Containing Materials (RACM) from a facility component. A renovation could be, but not limited to, any interior renovation or remodel not affecting load-supporting structural members or a roof replacement.

Surfacing means any material that was sprayed-on or troweled-on, or otherwise applied to surfaces, such as acoustical plaster on ceilings and fireproofing materials on structural members, or other materials on surfaces for acoustical, fireproofing, or other purposes.

Thermal Systems Insulation means material applied to pipes, fittings, boilers, breeching, tanks, ducts, or other interior structural components to prevent heat loss or gain, or water condensation, or for other purposes.

Transmission Electron Microscopy means a method of microscopic analysis, which utilizes an electron beam that is focused onto a thin sample. As the beam penetrates (transmits) through the sample, the difference densities produce an image on a fluorescent screen from which samples can be identified and counted. Also used for analyzing air samples for asbestos.

Key to Common Asbestos Related Abbreviations

ACMAsbestos-Containing Material

ACBMAsbestos-Containing Building Material

AHERA Asbestos Hazard Emergency Response Act

EDI – EXCELLENCE, DEDICATION & INNOVATION

(312) 345-1400 • WWW.ENVDESIGNI.COM

CFR Code of Federal Regulations
DOT Department of Transportation
EPA Environmental Protection Agency
FR Federal Register
HEPA High Efficiency Particulate Air
HVAC Heating, Ventilating and Air Conditioning Systems
NESHAP National Emission Standards for Hazardous Air Pollutants
NIOSH National Institute of Occupational Safety and Health
NIST National Institute for Standards and Technology
NVLAP National Voluntary Laboratory Accreditation
Program
OSHA Occupational Safety and Health Administration
PACM Presumed Asbestos Containing Material
PLM Polarized Light Microscopy
RACM Regulated Asbestos Containing Material
TEM Transmission Electron Microscopy
TSI Thermal Systems Insulation

APPENDIX A

Table I - Asbestos Survey Analytical Summary

MATERIAL CODE	MATERIAL DESCRIPTION	APPROX. QUANTITY	APPROX. LOCATION	LAB RESULTS
HA 1-01	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND
HA 1-01 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	PC 2.1% Chrysotile
HA 1-02	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND
HA 1-02 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	Not Analyzed
HA 1-03	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND
HA 1-03 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	Not Analyzed
HA 1-04	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND
HA 1-04 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	Not Analyzed
HA 1-05	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND

MATERIAL CODE	MATERIAL DESCRIPTION	APPROX. QUANTITY	APPROX. LOCATION	LAB RESULTS
HA 1-05 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	Not Analyzed
HA 1-06	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND
HA 1-06 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	Not Analyzed
HA 1-07	12" x 12" Tan Floor Tile	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	ND
HA 1-07 (L2)	12" x 12" Tan Floor Tile Mastic	~ 22,000 SF	Ground Floor, Rooms 116, 121, 105, North Hallway, Basement, Lunchroom, B4, B5, Classrooms	Not Analyzed
HA 2-08	Brown Baseboard and Adhesive		Classrooms, Ground Floor, Lunchroom, Basement	ND
HA 2-09	Brown Baseboard and Adhesive		Classrooms, Ground Floor, Lunchroom, Basement	ND
HA 2-10	Brown Baseboard and Adhesive		Classrooms, Ground Floor, Lunchroom, Basement	ND
HA 3-11	Black Baseboard and Adhesive		Lunchroom, Ground Floor, Room 103	ND
HA 3-12	Black Baseboard and Adhesive		Lunchroom, Ground Floor, Room 103	ND
HA 3-13	Black Baseboard and Adhesive		Lunchroom, Ground Floor, Room 103	ND
HA 4-14	Blue Baseboard and Adhesive		Room 118, North Hall, South Hall	ND
HA 4-15	Blue Baseboard and Adhesive		Room 118, North Hall, South Hall	ND
HA 4-16	Blue Baseboard and Adhesive		Room 118, North Hall, South Hall	ND
HA 5-17	12" x 12" Black Floor Tile and Black Mastic		Room 127	ND
HA 5-18	12" x 12" Black Floor Tile and Black Mastic		Room 127	ND

MATERIAL CODE	MATERIAL DESCRIPTION	APPROX. QUANTITY	APPROX. LOCATION	LAB RESULTS
HA 5-19	12" x 12" Black Floor Tile and Black Mastic		Room 127	ND
HA 6-20	12" x 12" Red Floor Tile and Black Mastic		Room 127	ND
HA 6-21	12" x 12" Red Floor Tile and Black Mastic		Room 127	ND
HA 6-22	12" x 12" Red Floor Tile and Black Mastic		Room 127	ND
HA 7-23	12" x 12" White Floor Tile	~ 5,000 SF	Computer Lab, Ground Floor, Rooms 131, 132, 102	ND
HA 7-23 (L2)	12" x 12" White Floor Tile Mastic	~ 5,000 SF	Computer Lab, Ground Floor, Rooms 131, 132, 102	PC 3.2% Chrysotile
HA 7-24	12" x 12" White Floor Tile	~ 5,000 SF	Computer Lab, Ground Floor, Rooms 131, 132, 102	ND
HA 7-24 (L2)	12" x 12" White Floor Tile Mastic	~ 5,000 SF	Computer Lab, Ground Floor, Rooms 131, 132, 102	Not Analyzed
HA 7-25	12" x 12" White Floor Tile	~ 5,000 SF	Computer Lab, Ground Floor, Rooms 131, 132, 102	ND
HA 7-25 (L2)	12" x 12" White Floor Tile Mastic	~ 5,000 SF	Computer Lab, Ground Floor, Rooms 131, 132, 102	Not Analyzed
HA 8-26	2' x 4' Ceiling Tile		Throughout	ND
HA 8-27	2' x 4' Ceiling Tile		Throughout	ND
HA 8-28	2' x 4' Ceiling Tile		Throughout	ND
HA 8-29	2' x 4' Ceiling Tile		Throughout	ND
HA 8-30	2' x 4' Ceiling Tile		Throughout	ND
HA 9-31	Drywall, Tape and Joint Compound		Throughout	ND
HA 9-32	Drywall, Tape and Joint Compound		Throughout	ND
HA 9-33	Drywall, Tape and Joint Compound		Throughout	ND
HA 9-34	Drywall, Tape and Joint Compound		Throughout	ND
HA 9-35	Drywall, Tape and Joint Compound		Throughout	ND
HA 9-36	Drywall, Tape and Joint Compound		Throughout	ND
HA 9-37	Drywall, Tape and Joint Compound		Throughout	ND
HA 10-38	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	PC 7.3% Chrysotile

MATERIAL CODE	MATERIAL DESCRIPTION	APPROX. QUANTITY	APPROX. LOCATION	LAB RESULTS
HA 10-39	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	Not Analyzed
HA 10-40	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	Not Analyzed
HA 10-41	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	Not Analyzed
HA 10-42	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	Not Analyzed
HA 10-43	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	Not Analyzed
HA 10-44	Textured Plaster	~ 37,000 SF	Structural Beams Above Drop Ceiling Throughout	Not Analyzed
HA 11-45	Window Glaze		Around Windows	ND
HA 11-46	Window Glaze		Around Windows	ND
HA 11-47	Window Glaze		Around Windows	ND
HA 12-48	Black Mastic for Red Carpet	~ 3,000 SF	Rooms 125, 130	PC 3.3% Chrysotile
HA 12-49	Black Mastic for Red Carpet	~ 3,000 SF	Rooms 125, 130	Not Analyzed
HA 12-50	Black Mastic for Red Carpet	~ 3,000 SF	Rooms 125, 130	Not Analyzed
Historical Data from "Asbestos Survey" December 1990				
S-01	Spray-on Textured Ceiling	~ 37,000 SF	On Decking Throughout Building	5%-10% Asbestos

APPENDIX B

Asbestos Laboratory Results, Laboratory Certification and Chain-of-Custody

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443586	Analyst Observation: Tan Floor Tile	Location: Ground Floor/Rm 116
Client No.: HA1-01	Client Description: Tan 12" x 12" Floor Tile And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443586(L2)	Analyst Observation: Black Mastic	Location: Ground Floor/Rm 116
Client No.: HA1-01	Client Description: Tan 12" x 12" Floor Tile And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>PC 2.1 Chrysotile</i>	None Detected	97.9

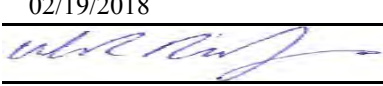
Lab No.: 6443587	Analyst Observation: Tan Floor Tile	Location: Ground Floor/Rm 121
Client No.: HA1-02	Client Description: Tan 12" x 12" Floor Tile And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

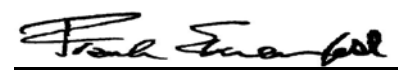
Lab No.: 6443588	Analyst Observation: Tan Floor Tile	Location: Ground Floor/Rm 105
Client No.: HA1-03	Client Description: Tan 12" x 12" Floor Tile And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443589	Analyst Observation: Tan Floor Tile	Location: Ground Floor/N. Hall
Client No.: HA1-04	Client Description: Tan 12" x 12" Floor Tile And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443590	Analyst Observation: Tan Floor Tile	Location: Basement/Lunch Rm
Client No.: HA1-05	Client Description: Tan 12" x 12" Floor Tile And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443590(L2) Client No.: HA1-05 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Mastic Client Description: Tan 12" x 12" Floor Tile And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Lunch Rm Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	---

Lab No.: 6443591 Client No.: HA1-06 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Floor Tile Client Description: Tan 12" x 12" Floor Tile And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Rm B4 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	--


Lab No.: 6443592 Client No.: HA1-07 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Floor Tile Client Description: Tan 12" x 12" Floor Tile And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Rm B5 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	--

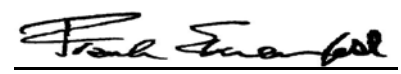
Lab No.: 6443593 Client No.: HA2-08 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Brown Cove Base Client Description: Brown B.B. And Adhesive <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 121 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

Lab No.: 6443593(L2) Client No.: HA2-08 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Brown Mastic Client Description: Brown B.B. And Adhesive <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 121 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	---

Lab No.: 6443593(L3) Client No.: HA2-08 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Joint Compound Client Description: Brown B.B. And Adhesive <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 121 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	---

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443594	Analyst Observation: Brown Cove Base	Location: Ground Floor/Rm 132
Client No.: HA2-09	Client Description: Brown B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443594(L2)	Analyst Observation: Brown Mastic	Location: Ground Floor/Rm 132
Client No.: HA2-09	Client Description: Brown B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100


Lab No.: 6443594(L3)	Analyst Observation: Tan Joint Compound	Location: Ground Floor/Rm 132
Client No.: HA2-09	Client Description: Brown B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

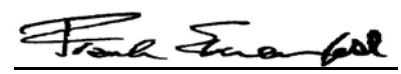
Lab No.: 6443595	Analyst Observation: Brown Cove Base	Location: Basement/Hall
Client No.: HA2-10	Client Description: Brown B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443595(L2)	Analyst Observation: Brown Mastic	Location: Basement/Hall
Client No.: HA2-10	Client Description: Brown B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443595(L3)	Analyst Observation: Tan Joint Compound	Location: Basement/Hall
Client No.: HA2-10	Client Description: Brown B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443596	Analyst Observation: Black Cove Base	Location: Ground Floor/Rm 127
Client No.: HA3-11	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443596(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 127
Client No.: HA3-11	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

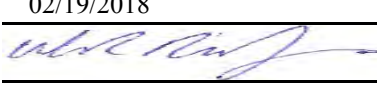
Lab No.: 6443596(L3)	Analyst Observation: Tan Joint Compound	Location: Ground Floor/Rm 127
Client No.: HA3-11	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

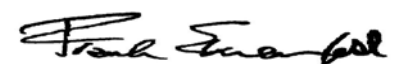
Lab No.: 6443597	Analyst Observation: Black Cove Base	Location: Ground Floor/Rm 102
Client No.: HA3-12	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443597(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 102
Client No.: HA3-12	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443597(L3)	Analyst Observation: Tan Joint Compound	Location: Ground Floor/Rm 102
Client No.: HA3-12	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443598	Analyst Observation: Black Cove Base	Location: Ground Floor/Rm 102
Client No.: HA3-13	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443598(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 102
Client No.: HA3-13	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100


Lab No.: 6443598(L3)	Analyst Observation: Tan Joint Compound	Location: Ground Floor/Rm 102
Client No.: HA3-13	Client Description: Black B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

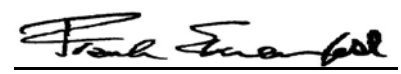
Lab No.: 6443599	Analyst Observation: Blue Cove Base	Location: Ground Floor/Rm 118
Client No.: HA4-14	Client Description: Blue B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443599(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 118
Client No.: HA4-14	Client Description: Blue B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443600	Analyst Observation: Blue Cove Base	Location: Ground Floor/W. Hall
Client No.: HA4-15	Client Description: Blue B.B. And Adhesive	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443600(L2)
Client No.: HA4-15

Analyst Observation: Tan Mastic
Client Description: Blue B.B. And Adhesive

Location: Ground Floor/W. Hall
Facility:

Percent Asbestos:
None Detected

Percent Non-Asbestos Fibrous Material:
None Detected

Percent Non-Fibrous Material:
100

Lab No.: 6443600(L3)
Client No.: HA4-15

Analyst Observation: Tan Joint Compound
Client Description: Blue B.B. And Adhesive

Location: Ground Floor/W. Hall
Facility:

Percent Asbestos:
None Detected

Percent Non-Asbestos Fibrous Material:
None Detected

Percent Non-Fibrous Material:
100

Lab No.: 6443601
Client No.: HA4-16

Analyst Observation: Blue Cove Base
Client Description: Blue B.B. And Adhesive

Location: Ground Floor/S. Hall
Facility:

Percent Asbestos:
None Detected

Percent Non-Asbestos Fibrous Material:
None Detected

Percent Non-Fibrous Material:
100

Lab No.: 6443601(L2)
Client No.: HA4-16

Analyst Observation: Tan Mastic
Client Description: Blue B.B. And Adhesive

Location: Ground Floor/S. Hall
Facility:

Percent Asbestos:
None Detected

Percent Non-Asbestos Fibrous Material:
None Detected

Percent Non-Fibrous Material:
100

Lab No.: 6443601(L3)
Client No.: HA4-16

Analyst Observation: Tan Joint Compound
Client Description: Blue B.B. And Adhesive

Location: Ground Floor/S. Hall
Facility:

Percent Asbestos:
None Detected

Percent Non-Asbestos Fibrous Material:
None Detected

Percent Non-Fibrous Material:
100

Lab No.: 6443602
Client No.: HA5-17

Analyst Observation: Black Floor Tile
Client Description: Black 12" x 12" FT And Mastic

Location: Ground Floor/Rm 127
Facility:

Percent Asbestos:
None Detected

Percent Non-Asbestos Fibrous Material:
None Detected

Percent Non-Fibrous Material:
100

Please refer to the Appendix of this report for further information regarding your analysis.

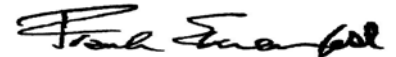
Date Received: 2/12/2018

Date Analyzed: 02/19/2018

Signature:

Analyst: Rodney Redman

Approved By:



Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443602(L2)	Analyst Observation: Yellow Mastic	Location: Ground Floor/Rm 127
Client No.: HA5-17	Client Description: Black 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443603	Analyst Observation: Black Floor Tile	Location: Ground Floor/Rm 127
Client No.: HA5-18	Client Description: Black 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100


Lab No.: 6443603(L2)	Analyst Observation: Yellow Mastic	Location: Ground Floor/Rm 127
Client No.: HA5-18	Client Description: Black 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

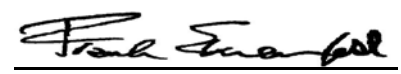
Lab No.: 6443604	Analyst Observation: Black Floor Tile	Location: Ground Floor/Rm 127
Client No.: HA5-19	Client Description: Black 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443604(L2)	Analyst Observation: Yellow Mastic	Location: Ground Floor/Rm 127
Client No.: HA5-19	Client Description: Black 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443605	Analyst Observation: Red Floor Tile	Location: Ground Floor/Rm 127
Client No.: HA6-20	Client Description: Red 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443605(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 127
Client No.: HA6-20	Client Description: Red 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443606	Analyst Observation: Red Floor Tile	Location: Ground Floor/Rm 127
Client No.: HA6-21	Client Description: Red 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100


Lab No.: 6443606(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 127
Client No.: HA6-21	Client Description: Red 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

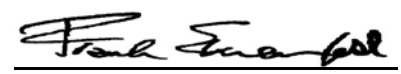
Lab No.: 6443607	Analyst Observation: Red Floor Tile	Location: Ground Floor/Rm 127
Client No.: HA6-22	Client Description: Red 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443607(L2)	Analyst Observation: Tan Mastic	Location: Ground Floor/Rm 127
Client No.: HA6-22	Client Description: Red 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443608	Analyst Observation: Tan Floor Tile	Location: Ground Floor/Rm 102
Client No.: HA7-23	Client Description: White 12" x 12" FT And Mastic	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443608(L2)
Client No.: HA7-23

Percent Asbestos:
None Detected

Analyst Observation: Yellow Mastic
Client Description: White 12" x 12" FT And Mastic

Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Rm 102
Facility:

Percent Non-Fibrous Material:
100

Lab No.: 6443608(L3)
Client No.: HA7-23

Percent Asbestos:
None Detected

Analyst Observation: Tan Floor Tile
Client Description: White 12" x 12" FT And Mastic

Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Rm 102
Facility:

Percent Non-Fibrous Material:
100

Lab No.: 6443608(L4)
Client No.: HA7-23

Percent Asbestos:
PC 3.2 Chrysotile

Analyst Observation: Black Mastic
Client Description: White 12" x 12" FT And Mastic

Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Rm 102
Facility:

Percent Non-Fibrous Material:
96.8

Lab No.: 6443608(L5)
Client No.: HA7-23

Percent Asbestos:
None Detected

Analyst Observation: Tan Cementitious
Client Description: White 12" x 12" FT And Mastic

Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Rm 102
Facility:

Percent Non-Fibrous Material:
100

Lab No.: 6443609
Client No.: HA7-24

Percent Asbestos:
None Detected

Analyst Observation: Tan Floor Tile
Client Description: White 12" x 12" FT And Mastic

Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Rm 131
Facility:

Percent Non-Fibrous Material:
100

Lab No.: 6443609(L2)
Client No.: HA7-24

Percent Asbestos:
None Detected

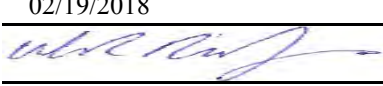
Analyst Observation: Yellow/Grey Mastic/Leveling Compound

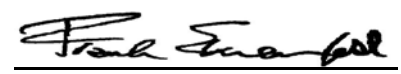
Client Description: White 12" x 12" FT And Mastic
Percent Non-Asbestos Fibrous Material:
15 Cellulose

Location: Ground Floor/Rm 131
Facility:

Percent Non-Fibrous Material:
85

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443609(L3) Client No.: HA7-24 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Floor Tile Client Description: White 12" x 12" FT And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 131 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	---

Lab No.: 6443610 Client No.: HA7-25 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Floor Tile Client Description: White 12" x 12" FT And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 132 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	---


Lab No.: 6443610(L2) Client No.: HA7-25 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Yellow Mastic Client Description: White 12" x 12" FT And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 132 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

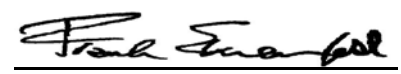
Lab No.: 6443610(L3) Client No.: HA7-25 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Floor Tile Client Description: White 12" x 12" FT And Mastic <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Floor/Rm 132 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	--	---

Lab No.: 6443611 Client No.: HA8-26 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Ceiling Tile Client Description: 2' x 4' Ceiling Tile <u>Percent Non-Asbestos Fibrous Material:</u> 30 Cellulose 30 Fibrous Glass	Location: Ground Floor/Rm 125 Facility: <u>Percent Non-Fibrous Material:</u> 40
--	--	--

Lab No.: 6443612 Client No.: HA8-27 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Ceiling Tile Client Description: 2' x 4' Ceiling Tile <u>Percent Non-Asbestos Fibrous Material:</u> 30 Cellulose 30 Fibrous Glass	Location: Ground Floor/Rm 115 Facility: <u>Percent Non-Fibrous Material:</u> 40
--	--	--

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443613
Client No.: HA8-28

Analyst Observation: Off-White Ceiling Tile
Client Description: 2' x 4' Ceiling Tile
Percent Asbestos:
None Detected
Percent Non-Asbestos Fibrous Material:
30 Cellulose
30 Fibrous Glass

Location: Ground Floor/Rm 130
Facility:
Percent Non-Fibrous Material:
40

Lab No.: 6443614
Client No.: HA8-29

Analyst Observation: Off-White Ceiling Tile
Client Description: 2' x 4' Ceiling Tile
Percent Asbestos:
None Detected
Percent Non-Asbestos Fibrous Material:
30 Cellulose
30 Fibrous Glass

Location: Basement/Hall
Facility:
Percent Non-Fibrous Material:
40

Lab No.: 6443615
Client No.: HA8-30

Analyst Observation: Off-White Ceiling Tile
Client Description: 2' x 4' Ceiling Tile
Percent Asbestos:
None Detected
Percent Non-Asbestos Fibrous Material:
30 Cellulose
30 Fibrous Glass

Location: Basement/Lunch Rm
Facility:
Percent Non-Fibrous Material:
40

Lab No.: 6443616
Client No.: HA9-31

Analyst Observation: Off-White Drywall
Client Description: Drywall And Compound
Percent Asbestos:
None Detected
Percent Non-Asbestos Fibrous Material:
5 Fibrous Glass

Location: Ground Level/Rm 116
Facility:
Percent Non-Fibrous Material:
95

Lab No.: 6443616(L2)
Client No.: HA9-31

Analyst Observation: Tan Joint Compound
Client Description: Drywall And Compound
Percent Asbestos:
None Detected
Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Level/Rm 116
Facility:
Percent Non-Fibrous Material:
100

Lab No.: 6443617
Client No.: HA9-32

Analyst Observation: Off-White Drywall
Client Description: Drywall And Compound
Percent Asbestos:
None Detected
Percent Non-Asbestos Fibrous Material:
5 Fibrous Glass

Location: Ground Level/Rm 127
Facility:
Percent Non-Fibrous Material:
95

Please refer to the Appendix of this report for further information regarding your analysis.

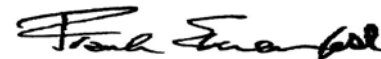
Date Received: 2/12/2018

Date Analyzed: 02/19/2018

Signature:

Analyst: Rodney Redman

Approved By:



Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443617(L2) Client No.: HA9-32 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Level/Rm 127 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

Lab No.: 6443618 Client No.: HA9-33 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Drywall Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> 5 Fibrous Glass	Location: Ground Level/Rm 105 Facility: <u>Percent Non-Fibrous Material:</u> 95
--	--	--


Lab No.: 6443618(L2) Client No.: HA9-33 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Level/Rm 105 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

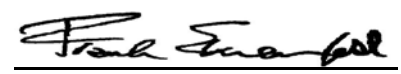
Lab No.: 6443619 Client No.: HA9-34 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Drywall Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> 5 Fibrous Glass	Location: Ground Level/Rm 112 Facility: <u>Percent Non-Fibrous Material:</u> 95
--	--	--

Lab No.: 6443619(L2) Client No.: HA9-34 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Ground Level/Rm 112 Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

Lab No.: 6443620 Client No.: HA9-35 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Drywall Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> 5 Fibrous Glass	Location: Basement/Lunch Rm Facility: <u>Percent Non-Fibrous Material:</u> 95
--	--	--

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443620(L2) Client No.: HA9-35 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Lunch Rm Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

Lab No.: 6443620(L3) Client No.: HA9-35 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Lunch Rm Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

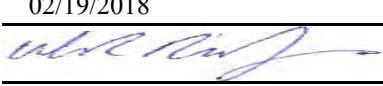
Lab No.: 6443621 Client No.: HA9-36 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Drywall Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> 5 Fibrous Glass	Location: Basement/Hall Facility: <u>Percent Non-Fibrous Material:</u> 95
--	--	--

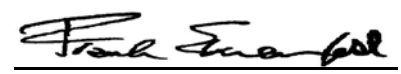
Lab No.: 6443621(L2) Client No.: HA9-36 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Hall Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

Lab No.: 6443621(L3) Client No.: HA9-36 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Tan Joint Compound Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> None Detected	Location: Basement/Hall Facility: <u>Percent Non-Fibrous Material:</u> 100
--	---	---

Lab No.: 6443622 Client No.: HA9-37 <u>Percent Asbestos:</u> <i>None Detected</i>	Analyst Observation: Off-White Drywall Client Description: Drywall And Compound <u>Percent Non-Asbestos Fibrous Material:</u> 5 Fibrous Glass	Location: Basement/Rm B4 Facility: <u>Percent Non-Fibrous Material:</u> 95
--	--	---

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443622(L2)	Analyst Observation: Off-White Joint Compound	Location: Basement/Rm B4
Client No.: HA9-37	Client Description: Drywall And Compound	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443622(L3)	Analyst Observation: Tan Joint Compound	Location: Basement/Rm B4
Client No.: HA9-37	Client Description: Drywall And Compound	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100


Lab No.: 6443623	Analyst Observation: Off-White/Tan Texture/Plaster	Location: Ground Level/Rm 125
Client No.: HA10-38	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>PC 7.3 Chrysotile</i>	None Detected	92.7

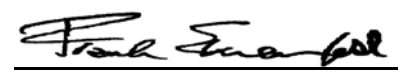
Lab No.: 6443624	Analyst Observation: Sample Not Analyzed	Location: Ground Level/E. Hall
Client No.: HA10-39	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>Sample Not Analyzed</i>	Sample Not Analyzed	

Lab No.: 6443625	Analyst Observation: Sample Not Analyzed	Location: Ground Level/Rm 111
Client No.: HA10-40	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>Sample Not Analyzed</i>	Sample Not Analyzed	

Lab No.: 6443626	Analyst Observation: Sample Not Analyzed	Location: Ground Level/Rm 112
Client No.: HA10-41	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>Sample Not Analyzed</i>	Sample Not Analyzed	

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443627	Analyst Observation: Sample Not Analyzed	Location: Basement/Hall
Client No.: HA10-42	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>Sample Not Analyzed</i>	Sample Not Analyzed	

Lab No.: 6443628	Analyst Observation: Sample Not Analyzed	Location: Basement/Lunch Rm E.
Client No.: HA10-43	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>Sample Not Analyzed</i>	Sample Not Analyzed	

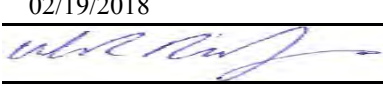
Lab No.: 6443629	Analyst Observation: Sample Not Analyzed	Location: Basement/Lunch Rm W.
Client No.: HA10-44	Client Description: Textured Plaster	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>Sample Not Analyzed</i>	Sample Not Analyzed	

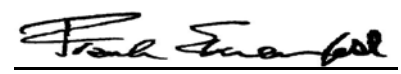
Lab No.: 6443630	Analyst Observation: Black Insulation	Location: Ground Floor/Room 101
Client No.: HA11-45	Client Description: Window Glaze	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443631	Analyst Observation: Black Insulation	Location: Ground Floor/Room 125
Client No.: HA11-46	Client Description: Window Glaze	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Lab No.: 6443632	Analyst Observation: Black Insulation	Location: Ground Floor/Room 102
Client No.: HA11-47	Client Description: Window Glaze	Facility:
<u>Percent Asbestos:</u>	<u>Percent Non-Asbestos Fibrous Material:</u>	<u>Percent Non-Fibrous Material:</u>
<i>None Detected</i>	None Detected	100

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W. Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

PLM BULK SAMPLE ANALYSIS SUMMARY

Lab No.: 6443633
Client No.: HA12-48
Percent Asbestos:
PC 3.3 Chrysotile

Analyst Observation: Black/Tan Mastic
Client Description: Red Carpet Adhesive
Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Room 125
Facility:
Percent Non-Fibrous Material:
96.7

Lab No.: 6443633(L2)
Client No.: HA12-48
Percent Asbestos:
None Detected

Analyst Observation: Tan Cementitious
Client Description: Red Carpet Adhesive
Percent Non-Asbestos Fibrous Material:
None Detected

Location: Ground Floor/Room 125
Facility:
Percent Non-Fibrous Material:
100

Lab No.: 6443634
Client No.: HA12-49
Percent Asbestos:
Sample Not Analyzed

Analyst Observation: Sample Not Analyzed
Client Description: Red Carpet Adhesive
Percent Non-Asbestos Fibrous Material:
Sample Not Analyzed

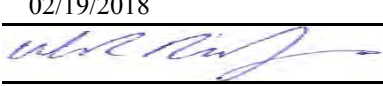
Location: Ground Floor/Room 125
Facility:
Percent Non-Fibrous Material:

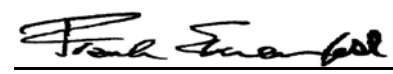
Lab No.: 6443635
Client No.: HA12-50
Percent Asbestos:
Sample Not Analyzed

Analyst Observation: Sample Not Analyzed
Client Description: Red Carpet Adhesive
Percent Non-Asbestos Fibrous Material:
Sample Not Analyzed

Location: Ground Floor/Room 130
Facility:
Percent Non-Fibrous Material:

Please refer to the Appendix of this report for further information regarding your analysis.

Date Received: 2/12/2018
Date Analyzed: 02/19/2018
Signature: 
Analyst: Rodney Redman

Approved By: 
Frank E. Ehrenfeld, III
Laboratory Director

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W.
Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

Appendix to Analytical Report

Customer Contact: Gary Flentge

Method: US EPA 600, R93-116

This appendix seeks to promote greater understanding of any observations, exceptions, special instructions, or circumstances that the laboratory needs to communicate to the client concerning the above samples. The information below is used to help promote your ability to make the most informed decisions for you and your customers. Please note the following points of contact for any questions you may have.

iATL Customer Service: customerservice@iatl.com

iATL Office Manager: cdavis@iatl.com

iATL Account Representative: Cassie Doherty

Sample Login Notes: See Batch Sheet Attached

Sample Matrix: Bulk Building Materials

Exceptions Noted: See Following Pages

General Terms, Warrants, Limits, Qualifiers:

General information about iATL capabilities and client/laboratory relationships and responsibilities are spelled out in iATL policies that are listed at www.iATL.com and in our Quality Assurance Manual per ISO 17025 standard requirements. The information therein is a representation of iATL definitions and policies for turnaround times, sample submittal, collection media, blank definitions, quantification issues and limit of detection, analytical methods and procedures, sub-contracting policies, results reporting options, fees, terms, and discounts, confidentiality, sample archival and disposal, and data interpretation.

iATL warrants the test results to be of a precision normal for the type and methodology employed for each sample submitted. iATL disclaims any other warrants, expressed or implied, including warranty of fitness for a particular purpose and warranty of merchantability. iATL accepts no legal responsibility for the purpose for which the client uses test results. Any analytical work performed must be governed by our Standard Terms and Conditions. Prices, methods and detection limits may be changed without notification. Please contact your Customer Service Representative for the most current information.

This confidential report relates only to those item(s) tested and does not represent an endorsement by NIST-NVLAP, AIHA LAP LLC, or any agency of local, state or province governments nor of any agency of the U.S. government.

This report shall not be reproduced except in full, without written approval of the laboratory.

Information Pertinent to this Report:

Analysis by US EPA 600 93-116: Determination of Asbestos in Bulk Building Materials by Polarized Light Microscopy (PLM).

Certifications:

- NIST-NVLAP No. 101165-0
- NYSDOH-ELAP No. 11021
- AIHA-LAP, LLC No. 100188

Quantification at <0.25% by volume is possible with this method. (PC) Indicates Stratified Point Count Method performed. (PC-Trace) means that asbestos was detected but is not quantifiable under the Point Counting regimen. Analysis includes all distinct separable layers in accordance with EPA 600 Method. If not reported or otherwise noted, layer is either not present or the client has specifically requested that it not be analyzed (ex. analyze until positive instructions). Small asbestos fibers may be missed by PLM due to resolution limitations of the optical microscope. Therefore, PLM is not consistently reliable in detecting asbestos in non-friable organically bound (NOB) materials. Quantitative transmission electron microscopy (TEM) is currently the only method that can pronounce materials as non-asbestos containing.

Analytical Methodology Alternatives: Your initial request for analysis may not have accounted for recent advances in regulatory requirements or advances in technology that are routinely used in similar situations for other qualified projects. You may have the option to explore additional analysis for further information. Below are a few options, listed as the matrix followed by the appropriate methodology. Also included are links to more information on our website.

Bulk Building Materials that are Non-Friable Organically Bound (NOB) by Gravimetric Reduction techniques employing PLM and TEM: ELAP 198.6 (PLM-NOB), ELAP 198.4 (TEM-NOB)

Loose Fill Vermiculite Insulation, Attic Insulation, Zonolite (copyright), etc.: US EPA 600 R-4/004 (multi-tiered analytical process)
Sprayed On Insulation/Fireproofing with Vermiculite (SOF-V): ELAP 198.8 (PLM-SOF-V)

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W.
Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

Soil, sludge, sediment, aggregate, and like materials analyzed for asbestos or other elongated mineral particles (ex. erionite, etc.): ASTM D7521, CARB 435, and other options available

Asbestos in Surface Dust according to one of ASTM's Methods (very dependent on sampling collection technique – by TEM): ASTM D 5755, D5756, or D6480

Various other asbestos matrices (air, water, etc.) and analytical methods are available.

Disclaimers / Qualifiers:

There may be some samples in this project that have a "NOTE:" associated with a sample result. We use added disclaimers or qualifiers to inform the client about something that requires further explanation. Here is a list with highlighted disclaimers that may be pertinent to this project. For a full explanation of these and other disclaimers, please inquire at customerservice@iatl.com.

- 1) Note: No mastic provided for analysis.
- 2) Note: Insufficient mastic provided for analysis.
- 3) Note: Insufficient material provided for analysis.
- 4) Note: Insufficient sample provided for QC reanalysis.
- 5) Note: Different material than indicated on Sample Log / Description.
- 6) Note: Sample not submitted.
- 7) Note: Attached to asbestos containing material.
- 8) Note: Received wet.
- 9) Note: Possible surface contamination.
- 10) Note: Not building material. 1% threshold may not apply.
- 11) Note: Recommend TEM-NOB analysis as per EPA recommendations.
- 12) Note: Asbestos detected but not quantifiable.
- 13) Note: Multiple identical samples submitted, only one analyzed.
- 14) Note: Analyzed by EPA 600/R-93/116. Point Counting detection limit at 0.080%.
- 15) Note: Analyzed by EPA 600/R-93/116. Point Counting detection limit at 0.125%.
- 16) Note: This sample contains >10% vermiculite mineral. See Appendix for Recommendations for Vermiculite Analysis.

Recommendations for Vermiculite Analysis:

Several analytical protocols exist for the analysis of asbestos in vermiculite. These analytical approaches vary depending upon the nature of the vermiculite mineral being tested (e.g. un-processed gänge, homogeneous exfoliated books of mica, or mixed mineral composites). Please contact your client representative for pricing and turnaround time options available.

iATL recommends initial testing using the EPA 600/R-93/116 method. This method is specifically designed for the analysis of asbestos in bulk building materials. It provides an acceptable starting point for primary screening of vermiculite for possible asbestos.

Results from this testing may be inconclusive. EPA suggests proceeding to a multi-tiered analysis involving wet separation techniques in conjunction with PLM and TEM gravimetric analysis (EPA 600/R-04/004).

For New York State customers, NYSDOH requires disclaimers and qualifiers for various vermiculite containing samples that direct analysis via ELAP198.6 and ELAP198.8 for samples that contain >10% vermiculite mineral where ELAP198.6 may be used to evaluate the asbestos content of the material. However, any test result using ELAP198.6 will be reported with the following disclaimer: "ELAP198.6 method does not remove vermiculite and may underestimate the level of asbestos present in a sample containing >10% vermiculite."

Further information on this method and other vermiculite and asbestos issues can be found at the following: Agency for Toxic Substances and Disease Registry (ATSDR) www.atsdr.cdc.gov, United States Geological Survey (USGS) www.minerals.usgs.gov/minerals/, US EPA www.epa.gov/asbestos. The USEPA also has an informative brochure "Current Best Practices for Vermiculite Attic Insulation" EPA 747F03001 May 2003, that may assist the health and remediation professional.

The following is a summary of the analytical process outlines in the EPA 600/R-04/004 Method:

- 1) **Analytical Step/Method:** Initial Screening by PLM, EPA 600R-93/116
Requirements/Comments: Minimum of 0.1 g of sample. ~0.25% LOQ for most samples.
- 2) **Analytical Step/Method:** Wet Separation by PLM Gravimetric Technique, EPA R-04/004
Requirements/Comments: Minimum 50g** of dry sample. Analysis of "Sinks" only.
- 3) **Analytical Step/Method:** Wet Separation by PLM Gravimetric Technique, EPA R-04/004

CERTIFICATE OF ANALYSIS

Client: Environmental Design International
33 W Monroe, Suite 1825
Chicago IL 60603

Report Date: 2/19/2018
Report No.: 557305 - PLM
Project: Westside Learning Center; 4624 W.
Madison St., Chicago, IL
Project No.: 1654.038

Client: ENV374

Requirements/Comments: Minimum 50g** of dry sample. Analysis of "Floats" only.

4)**Analytical Step/Method:** Wet Separation by TEM Gravimetric Technique, EPA R-04/004

Requirements/Comments: Minimum 50g** of dry sample. Analysis of "Sinks" only.

5)**Analytical Step/Method:** Wet Separation by TEM Gravimetric Technique, EPA R-04/004

Requirements/Comments: Minimum 50g** of dry sample. Analysis of "Suspension" only.

LOQ, Limit of Quantitation estimates for mass and volume analyses.

*With advance notice and confirmation by the laboratory.

**Approximately 1 Liter of sample in double-bagged container (~9x6 inch bag of sample).



Environmental Design
International inc.

CHAIN OF CUSTODY / ANALYSIS REQUEST FORM

33 West Monroe Street, Suite 1825, Chicago, IL 60603

P (312) 345-1400

F (312) 345-0529

Page

1 of 4

Client: Bailey Edward

Date: 2/2/18

Sampled by: Jarrett Lead

Location: Westside Learning Center

Site Address: 4624 W. Madison St. Chicago IL

of Samples: 47

EDl Project #: 1654-038 Date Collected: 2/2/18 Date Shipped: 2/2/18 Date Results Needed: 5 day TAT.

SAMPLE ID #	SAMPLE LOCATION/DESCRIPTION	COMP	MATRIX						METHOD PRESERVED				SAMPLING		VOLUME (L)	TIME (MINUTES)	# OF CONTAINERS	LABORATORY NUMBER
			WATER	SOIL	AIR	SLUDGE	OTHER	HCL	HNO3	H2SO4	ICE	NONE	OTHER	DATE	TIME			
HA 1-01	Ground Floor / Rm 116 / Tan 12"x12" Floor Tile	X												2/2/18	0000	6443586		PLN
02	/ Rm 121 / 4 Mastic															6443587		
03	/ Rm 105 /															6443588		
04	↓ / N. Hall /															6443589		
05	Basement / Lunch Rm /															6443590		
06	↓ / Rm B4 /															6443591		
07	↓ / Rm B5 /															6443592		
2-08	Ground Floor / Rm 121 / Brown B.B. & Adhesive															6443593		
09	↓ / Rm 132 /															6443594		
10	Basement / Hall /															6443595		
3-11	Ground Floor / Rm 127 / Black B.B. & Adhesive															6443596		
12	↓ / Rm 102 /															6443597		
13	↓ /															6443598		

Released By (Signature)	Date/Time	Delivery Method	Received By (Signature)	Date/Time
Jarrett Lead	2/2/18	Red EX	Jarrett Lead	2/2/18
rum	2-19-18	Red EX	rum	2-19-18

Comments: Please stop analysis at 1st positive. Please email results to rcicent@envdesign.com



Environmental Design
International inc.

CHAIN OF CUSTODY / ANALYSIS REQUEST FORM

33 West Monroe Street, Suite 1825, Chicago, IL 60603

P (312) 345-1400

F (312) 345-0529

Page 2 of 4

Client: Bailey Edward

Location: Westside Learning Center

Sampled by: Jarrett Land

Date: 2/8/18

Site Address: 4624 W. Madison St., Chicago, IL

of Samples: 47

EDI Project #: 1654.038 Date Collected: 2/9/18 Date Shipped: 2/9/18 Date Results Needed: 5 day TAT.

SAMPLE ID #	SAMPLE LOCATION/DESCRIPTION	COMP	GRAB	MATRIX						METHOD PRESERVED						SAMPLING		VOLUME (L)	TIME (MINUTES)	# OF CONTAINERS	LABORATORY NUMBER
				WATER	SOIL	AIR	SLUDGE	OTHER	HCL	HNO3	H2SO4	ICE	NONE	OTHER	DATE	TIME					
14A 4-14	Ground Floor / Rm 103 / Blue B.B. +		X												2/9/18 9:00	6443590	X	10LW			
15	/ W. Hall / adhesive															6443600					
16	/ S. Hall /															6443601					
5-17	/ Rm 127 / Black 12"x12" F.T. +															6443602					
18	/ / / Mastic															6443603					
19	/ / /															6443604					
6-20	/ / / Red 12"x12" F.T. +															6443605					
21	/ / / mastic															6443606					
22	/ / /															6443607					
7-23	/ Rm 102 / White 12"x12" F.T. +															6443608					
24	/ Rm 131 / mastic															6443609					
25	/ Rm 132 /															6443610					
8-26	/ Rm 125 / 2'x4' Ceiling Tile															6443611					
Released By (Signature)				Date/Time				Delivery Method				Received By (Signature)				Date/Time					
Jarrett Land				2/9/18				FedEx													

Comments: Please stop analysis at 1st positive. Please email results to rcic@nasenvdesigni.com



Environmental Design
International inc.

CHAIN OF CUSTODY / ANALYSIS REQUEST FORM

33 West Monroe Street, Suite 1825, Chicago, IL 60603

P (312) 345-1400

F (312) 345-0529

Page

394

Client: Bailey Edward
Location: Westside Learning Center
Date: 2/18/18
Sampled by: Jarrett Land

Site Address: 4624 W. Madison St., Chicago, IL

EDI Project #: 1684-038

Date Collected: 2/18/18

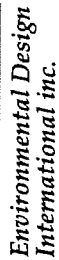
Date Shipped: 2/19/18

Date Results Needed: 5 day T.H.T.

of Samples: 47

SAMPLE ID #	SAMPLE LOCATION/DESCRIPTION	COMP	GRAB	MATRIX							METHOD PRESERVED				SAMPLING		VOLUME (L)	TIME (MINUTES)	# OF CONTAINERS	LABORATORY NUMBER
				WATER	SOIL	AIR	SLUDGE	OTHER	HCL	HNO3	H2SO4	ICE	NONE	OTHER	DATE	TIME				
HA 8-27	Ground Level/Rm 115/2'x4' ceiling tile	X																		
28	↓ / Rm 130/																			
29	Basement / Hall /																			
30	↓ / Lunch Rm /																			
9-31	Ground Level/Rm 116/Dayrall & Corridor																			
32	↓ / Rm 127/																			
33	↓ / Rm 105/																			
34	↓ / Rm 112/																			
35	Basement / Lunch Rm /																			
36	↓ / Hall /																			
37	↓ / Rm B4 /																			
10-38	Ground Level/Rm 125/Textured Plaster																			
39	↓ / E. Hall /																			
Released By (Signature)		Date/Time		Delivery Method		Received By (Signature)		Date/Time												
Jarrett Land		2/19/18		Fed Ex																

Comments: Please stop analysis at 1st positive. Please email results to rc@envidesign.com



33 West Monroe Street, Suite 1825, Chicago, IL 60603

P (312) 345-1400 F (312) 345-0529

P (312) 345-1400

F (312) 345-0529

Date: 2/28/18

Sampled by: Tarrett Good

of Samples: 47

Date Collected: 2/8/18

Date Shipped:

Date Results N

ded: 5 day T.A.T.

[illegible]

Released By (Signature)

Date/Time

Delivery Method

Received By (Signature)

Date/Time

Garrett A. ...

2/2/88

Red Fox

Comments: Please stop analysis at 1st positive. Please email results to reicenas@envdesign.com

APPENDIX C

Lead Survey



Index	Time	COMPONENT	SUBSTRATE	SIDE	CONDITION	COLOR	SITE	FLOOR	ROOM	CALIBRATE	Results
1	2018-02-09 09:07										
2	2018-02-09 09:13						4624 W. Madison	FIRST		RED IN	Positive
3	2018-02-09 09:13						4624 W. Madison	FIRST		RED IN	Positive
4	2018-02-09 09:15						4624 W. Madison	FIRST		RED IN	Positive
5	2018-02-09 09:17	WALL	DRYWALL	A	FAIR	TAN	4624 W. Madison	FIRST	123		Negative
6	2018-02-09 09:17	WALL	DRYWALL	B	FAIR	TAN	4624 W. Madison	FIRST	123		Negative
7	2018-02-09 09:17	WALL	DRYWALL	C	FAIR	TAN	4624 W. Madison	FIRST	123		Negative
8	2018-02-09 09:18	WALL	DRYWALL	D	FAIR	TAN	4624 W. Madison	FIRST	123		Negative
9	2018-02-09 09:19	WINDOW FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	123		Negative
10	2018-02-09 09:19	RADIATOR COVER	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	123		Negative
11	2018-02-09 09:21	WALL	DRYWALL	A	FAIR	BLUE	4624 W. Madison	FIRST	HALL		Negative
12	2018-02-09 09:22	WALL	DRYWALL	B	FAIR	BLUE	4624 W. Madison	FIRST	HALL		Negative
13	2018-02-09 09:23	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	122		Negative
14	2018-02-09 09:23	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	122		Negative
15	2018-02-09 09:24	DOOR FRAME	METAL	B	FAIR	BLUE	4624 W. Madison	FIRST	122		Negative
16	2018-02-09 09:24	DOOR FRAME	METAL	A	FAIR	BROWN	4624 W. Madison	FIRST	122		Negative
17	2018-02-09 09:25	WALL	DRYWALL	A	FAIR	TAN	4624 W. Madison	FIRST	122		Negative
18	2018-02-09 09:25	WALL	DRYWALL	B	FAIR	TAN	4624 W. Madison	FIRST	122		Negative
19	2018-02-09 09:26	WALL	DRYWALL	C	FAIR	TAN	4624 W. Madison	FIRST	122		Negative
20	2018-02-09 09:26	WALL	DRYWALL	D	FAIR	TAN	4624 W. Madison	FIRST	122		Negative
21	2018-02-09 09:27	WINDOW FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	122		Negative
22	2018-02-09 09:27	RADIATOR COVER	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	122		Negative
23	2018-02-09 09:28	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	120		Negative
24	2018-02-09 09:29	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	120		Negative
25	2018-02-09 09:29	WALL	DRYWALL	A	FAIR	BLUE	4624 W. Madison	FIRST	120		Negative
26	2018-02-09 09:30	WALL	DRYWALL	B	FAIR	BLUE	4624 W. Madison	FIRST	120		Negative
27	2018-02-09 09:30	WALL	DRYWALL	C	FAIR	BLUE	4624 W. Madison	FIRST	120		Negative
28	2018-02-09 09:30	WALL	DRYWALL	D	FAIR	BLUE	4624 W. Madison	FIRST	120		Negative
29	2018-02-09 09:31	WINDOW FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	120		Negative
30	2018-02-09 09:32	RADIATOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	120		Negative
31	2018-02-09 09:33	DOOR	METAL	A	FAIR	BROWN	4624 W. Madison	FIRST	132		Negative
32	2018-02-09 09:33	DOOR	METAL	B	FAIR	BLUE	4624 W. Madison	FIRST	132		Negative
33	2018-02-09 09:34	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	132		Negative
34	2018-02-09 09:35	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	FIRST	132		Negative



Index	Time	COMPONENT	SUBSTRATE	SIDE	CONDITION	COLOR	SITE	FLOOR	ROOM	CALIBRATE	Results
35	2018-02-09 09:35	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	FIRST	132		Negative
36	2018-02-09 09:35	WALL	DRYWALL	C	FAIR	WHITE	4624 W. Madison	FIRST	132		Negative
37	2018-02-09 09:36	WALL	DRYWALL	D	FAIR	WHITE	4624 W. Madison	FIRST	132		Negative
38	2018-02-09 09:37	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	119		Negative
39	2018-02-09 09:37	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	119		Negative
40	2018-02-09 09:38	WALL	DRYWALL	A	FAIR	BLUE	4624 W. Madison	FIRST	119		Negative
41	2018-02-09 09:38	WALL	DRYWALL	B	FAIR	BLUE	4624 W. Madison	FIRST	119		Negative
42	2018-02-09 09:38	WALL	DRYWALL	C	FAIR	BLUE	4624 W. Madison	FIRST	119		Negative
43	2018-02-09 09:39	WALL	DRYWALL	D	FAIR	BLUE	4624 W. Madison	FIRST	119		Negative
44	2018-02-09 09:40	WINDOW FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	119		Negative
45	2018-02-09 09:40	RADIATOR COVER	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	119		Negative
46	2018-02-09 09:42	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	117		Negative
47	2018-02-09 09:42	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	117		Negative
48	2018-02-09 09:42	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	117		Negative
49	2018-02-09 09:43	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	117		Negative
50	2018-02-09 09:43	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	FIRST	117		Negative
51	2018-02-09 09:44	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	FIRST	117		Negative
52	2018-02-09 09:44	WALL	DRYWALL	C	FAIR	WHITE	4624 W. Madison	FIRST	117		Negative
53	2018-02-09 09:45	WALL	DRYWALL	D	FAIR	WHITE	4624 W. Madison	FIRST	117		Negative
54	2018-02-09 09:45	RADIATOR COVER	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	117		Negative
55	2018-02-09 09:46	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	115		Negative
56	2018-02-09 09:47	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	115		Negative
57	2018-02-09 09:47	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	115		Negative
58	2018-02-09 09:47	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	115		Negative
59	2018-02-09 09:48	WALL	DRYWALL	A	FAIR	TAN	4624 W. Madison	FIRST	115		Negative
60	2018-02-09 09:48	WALL	DRYWALL	B	FAIR	TAN	4624 W. Madison	FIRST	115		Negative
61	2018-02-09 09:49	WALL	DRYWALL	C	FAIR	TAN	4624 W. Madison	FIRST	115		Negative
62	2018-02-09 09:49	WALL	DRYWALL	D	FAIR	TAN	4624 W. Madison	FIRST	115		Negative
63	2018-02-09 09:50	RADIATOR COVER	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	115		Negative
64	2018-02-09 09:51	WALL	CINDERBLOCK	A	FAIR	TAN	4624 W. Madison	FIRST	112		Negative
65	2018-02-09 09:53	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	111		Negative
66	2018-02-09 09:53	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	111		Negative
67	2018-02-09 09:53	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	111		Negative
68	2018-02-09 09:54	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	111		Negative



Index	Time	COMPONENT	SUBSTRATE	SIDE	CONDITION	COLOR	SITE	FLOOR	ROOM	CALIBRATE	Results
69	2018-02-09 09:54	WALL	DRYWALL	A	FAIR	TAN	4624 W. Madison	FIRST	111		Negative
70	2018-02-09 09:55	WALL	DRYWALL	B	FAIR	TAN	4624 W. Madison	FIRST	111		Negative
71	2018-02-09 09:55	WALL	DRYWALL	C	FAIR	TAN	4624 W. Madison	FIRST	111		Negative
72	2018-02-09 09:56	WALL	DRYWALL	D	FAIR	TAN	4624 W. Madison	FIRST	111		Negative
73	2018-02-09 09:58	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	130		Negative
74	2018-02-09 09:58	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	130		Negative
75	2018-02-09 09:59	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	130		Negative
76	2018-02-09 09:59	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	130		Negative
77	2018-02-09 10:01	WALL	CINDERBLOCK	A	FAIR	TAN	4624 W. Madison	FIRST	CLOSET		Negative
78	2018-02-09 10:03	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	104		Negative
79	2018-02-09 10:04	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	104		Negative
80	2018-02-09 10:04	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	104		Negative
81	2018-02-09 10:04	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	104		Negative
82	2018-02-09 10:05	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	FIRST	104		Negative
83	2018-02-09 10:06	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	FIRST	104		Negative
84	2018-02-09 10:06	WALL	DRYWALL	C	FAIR	WHITE	4624 W. Madison	FIRST	104		Negative
85	2018-02-09 10:07	WALL	DRYWALL	D	FAIR	WHITE	4624 W. Madison	FIRST	104		Negative
86	2018-02-09 10:08	DOOR	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	127		Negative
87	2018-02-09 10:08	DOOR FRAME	METAL	A	FAIR	BLUE	4624 W. Madison	FIRST	127		Negative
88	2018-02-09 10:09	DOOR	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	127		Negative
89	2018-02-09 10:09	DOOR FRAME	METAL	B	FAIR	BROWN	4624 W. Madison	FIRST	127		Negative
90	2018-02-09 10:10	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	FIRST	127		Negative
91	2018-02-09 10:10	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	FIRST	127		Negative
92	2018-02-09 10:11	WALL	DRYWALL	C	FAIR	RED	4624 W. Madison	FIRST	127		Negative
93	2018-02-09 10:11	WALL	DRYWALL	D	FAIR	RED	4624 W. Madison	FIRST	127		Negative
94	2018-02-09 10:13	WALL	DRYWALL	A	FAIR	BLUE	4624 W. Madison	FIRST	101		Negative
95	2018-02-09 10:13	WALL	DRYWALL	B	FAIR	BLUE	4624 W. Madison	FIRST	101		Negative
96	2018-02-09 10:14	COLUMN	DRYWALL	C	FAIR	BLUE	4624 W. Madison	FIRST	101		Negative
97	2018-02-09 10:15	WINDOW FRAME	METAL	C	FAIR	BROWN	4624 W. Madison	FIRST	101		Negative
98	2018-02-09 10:15	RADIATOR COVER	METAL	C	FAIR	BROWN	4624 W. Madison	FIRST	101		Negative
99	2018-02-09 10:16	WALL	DRYWALL	A	FAIR	BLUE	4624 W. Madison	FIRST	STAIR		Negative
100	2018-02-09 10:16	WALL	DRYWALL	B	FAIR	BLUE	4624 W. Madison	FIRST	STAIR		Negative
101	2018-02-09 10:18	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	BASEMENT	HALL		Negative
102	2018-02-09 10:18	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	BASEMENT	HALL		Negative



Index	Time	COMPONENT	SUBSTRATE	SIDE	CONDITION	COLOR	SITE	FLOOR	ROOM	CALIBRATE	Results
103	2018-02-09 10:19	DOOR	METAL	A	FAIR	BROWN	4624 W. Madison	BASEMENT	B4		Negative
104	2018-02-09 10:19	DOOR FRAME	METAL	A	FAIR	BROWN	4624 W. Madison	BASEMENT	B4		Negative
105	2018-02-09 10:20	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	BASEMENT	B4		Negative
106	2018-02-09 10:20	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	BASEMENT	B4		Negative
107	2018-02-09 10:21	WALL	DRYWALL	C	FAIR	WHITE	4624 W. Madison	BASEMENT	B4		Negative
108	2018-02-09 10:21	WALL	DRYWALL	D	FAIR	WHITE	4624 W. Madison	BASEMENT	B4		Negative
109	2018-02-09 10:22	WALL	DRYWALL	A	FAIR	WHITE	4624 W. Madison	BASEMENT	Lunchroom		Negative
110	2018-02-09 10:23	WALL	DRYWALL	B	FAIR	WHITE	4624 W. Madison	BASEMENT	Lunchroom		Negative
111	2018-02-09 10:23	WALL	DRYWALL	C	FAIR	WHITE	4624 W. Madison	BASEMENT	Lunchroom		Negative
112	2018-02-09 10:23	WALL	DRYWALL	D	FAIR	WHITE	4624 W. Madison	BASEMENT	Lunchroom		Negative
113	2018-02-09 10:24	DUCT	METAL	A	FAIR	WHITE	4624 W. Madison	BASEMENT	Lunchroom		Negative
114	2018-02-09 10:24	DUCT	METAL	B	FAIR	WHITE	4624 W. Madison	BASEMENT	Lunchroom		Negative
115	2018-02-09 10:26	DOOR	METAL	A	FAIR	BROWN	4624 W. Madison	BASEMENT	Lunchroom		Negative
116	2018-02-09 10:26	DOOR FRAME	METAL	A	FAIR	BROWN	4624 W. Madison	BASEMENT	Lunchroom		Negative
117	2018-02-09 10:27	WALL	CINDERBLOCK	A	FAIR	GREY	4624 W. Madison	BASEMENT	Storage		Negative
118	2018-02-09 10:27	WALL	CINDERBLOCK	B	FAIR	GREY	4624 W. Madison	BASEMENT	Storage		Negative
119	2018-02-09 10:27	WALL	CINDERBLOCK	C	FAIR	GREY	4624 W. Madison	BASEMENT	Storage		Negative
120	2018-02-09 10:28	WALL	CINDERBLOCK	D	FAIR	GREY	4624 W. Madison	BASEMENT	Storage		Negative
121	2018-02-09 10:28	FLOOR	CONCRETE	A	FAIR	GREY	4624 W. Madison	BASEMENT	Storage		Negative
122	2018-02-09 10:28	FLOOR	CONCRETE	D	FAIR	GREY	4624 W. Madison	BASEMENT	Storage		Negative
123	2018-02-09 10:32	DOOR	METAL	A	FAIR	BEIGE	4624 W. Madison	BASEMENT	Elevator		Negative
124	2018-02-09 10:33						4624 W. Madison			RED OUT	Positive
125	2018-02-09 10:33						4624 W. Madison			RED OUT	Negative
126	2018-02-09 10:35						4624 W. Madison			RED OUT	Positive
127	2018-02-09 10:35						4624 W. Madison			RED OUT	Positive

APPENDIX D

Employee Certifications



**ASBESTOS
PROFESSIONAL
LICENSE**

ID NUMBER
100 - 11233

ISSUED
1/24/2017

EXPIRES
05/15/2018

JARRETT M LAND
6139 SOUTH LOOMIS BLVD
CHICAGO, IL 60636

Environmental Health



ENDORSEMENTS**TC EXPIRES**

INSPECTOR

11/15/2017

PROJECT MANAGER
AIR SAMPLING PROFESSIONAL

10/8/2017

Alteration of this license shall result in legal action
This license issued under authority of the State of Illinois
Department of Public Health
This license is valid only when accompanied by a valid
training course certificate.

2017



OCCUPATIONAL TRAINING & SUPPLY, INC.

7233 S. Adams Street ♦ Willowbrook, IL 60527 ♦ (630) 655-3900 ♦ www.otssafety.com

Asbestos Building Inspector Refresher

Occupational Training & Supply, Inc. certifies that

Jarrett Land

has successfully completed the Asbestos Building Inspector Refresher course and has passed the competency exam with a minimum score of 70%. The course is accredited by the Illinois Department of Public Health and Indiana Department of Environmental Management for purposes of accreditation in accordance with EPA 40 CFR 763, Asbestos Hazard Emergency response Act (AHERA) and TSCA Title II.

Course Date: 11/10/2017

Exam Date: 11/10/2017

Expiration Date: 11/10/2018

Certificate Number: BIR1711104765

Kathy DeSalvo, Director



**LEAD RISK
ASSESSOR LICENSE**

LEAD ID ISSUED EXPIRES
013706 12/11/2017 1/31/2019

Jarrett M Land
6139 S. Loomis Blvd.
Chicago, IL 60636



ILLINOIS LEAD PROGRAM
Environmental Health

2017



OCCUPATIONAL TRAINING & SUPPLY, INC.

7233 S. Adams Street ♦ Willowbrook, IL 60527 ♦ (630) 655-3900 ♦ www.otssafety.com

Lead Risk Assessor Refresher

Occupational Training & Supply, Inc. certifies that

Jarrett Land

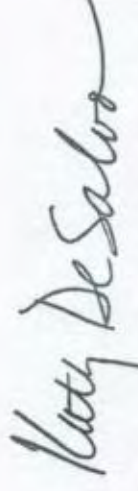
has successfully completed the Lead Risk Assessor Refresher course and has passed the competency exam with a minimum score of 70%.
This course is accredited by the Illinois Department of Public Health in accordance with the Illinois Lead Poisoning Prevention Code.

Course Date: 9/14/2017

Exam Date: 9/14/2017

Expiration Date: 9/14/2020

Certificate Number: LRAR1709144187


Kathy DeSalvo, Director

APPENDIX E

Previous Environmental Reports

ASBESTOS SURVEY

WEST SIDE LEARNING CENTER
4624 WEST MADISON STREET
CHICAGO, ILLINOIS

CERTIFIED PROJECT NO. C00022-006

PREPARED FOR:

CITY COLLEGES OF CHICAGO
226 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60606

DATE ISSUED: DECEMBER 11, 1990

The Asbestos Survey described herein was conducted by the undersigned, of Certified Engineering and Testing Company, Inc. (CERTIFIED). CERTIFIED's investigation consisted solely of the activities described in the Introduction to this report and is subject to the Limitations and Service Constraints provided in Appendix A.

Judy G. Gilbert
Judy Gilbert
Industrial Hygienist

12/10/90
(Date)

Robert Garrity (da)
Robert Garrity
Industrial Hygienist

12/10/90
(Date)

Asbestos Survey Report Reviewed and Approved By:

Jan B. Sheinson
Jan B. Sheinson
Branch Manager

12/12/90
(Date)

EXECUTIVE SUMMARY

CERTIFIED conducted an asbestos survey at West Side Learning Center, 4624 West Madison Street, Chicago, Illinois on July 19, 1990.

The objective of the survey was to identify and assess the condition of materials containing greater than one percent asbestos at West Side Learning Center. In addition, CERTIFIED was requested to recommend response actions and provide cost estimates for implementation of these response actions and for complete removal of all confirmed asbestos-containing materials (ACM). The survey was subject to the Limitations and Service Constraints found in Appendix A and included only those materials noted in the List of Investigated Materials in Appendix C.

The 37,000 square foot building was constructed in 1987. The single-story structure has a basement, and contains classrooms and offices.

Spray-on textured plaster (S-01) at the West Side Learning Center was found to contain asbestos. The material is in good condition and should be maintained under the provisions of an Operations and Maintenance (O&M) Program.

No asbestos was detected in the 2'x4' suspended ceiling tile (M-02) or 12"x12" beige floor tile (M-01).

The estimated cost to implement an O&M Program at the West Side Learning Center is \$7,500 - \$10,000. The estimated cost to remove all confirmed ACM is \$1,110,000. CERTIFIED, however, does not recommend full removal at this time.

TABLE OF CONTENTS

Executive Summary.....	iii
I. Introduction.....	1
II. Site Description.....	1
III. Methodology.....	1
IV. Findings and Recommendations.....	3
V. Cost Estimates.....	4

Table 1.....	76
Table 2.....	87
Table 3.....	88

Appendix A	Limitations and Service Constraints
Appendix B	Sample Analysis Results
Appendix C	List of Investigated Materials
Appendix D	Photographs
Appendix E	Floor Plans
Appendix F	AHERA Assessment Categories and Recommended Response Actions
Appendix G	Asbestos Management Schedule
Appendix H	Contractor Selection
Appendix I	Definitions

I. INTRODUCTION

Certified Engineering and Testing Company, Inc. (CERTIFIED) was retained by the City Colleges of Chicago to perform an asbestos survey at West Side Learning Center located at 4624 West Madison Street, Chicago, Illinois. The survey was conducted on July 19, 1990 and was authorized by the City Colleges of Chicago. CERTIFIED's representatives were accompanied on site by Mr. George Edwards, Chief Engineer.

The scope of work for the project, as provided to CERTIFIED by the City Colleges of Chicago, was to identify materials containing greater than one percent asbestos at West Side Learning Center and to assess their condition. In addition, CERTIFIED was requested to recommend response actions and provide cost estimates for implementation of these recommendations and for complete removal of all confirmed ACM. The survey was subject to the Limitations and Service Constraints found in Appendix A and included only those materials noted in the List of Investigated Materials in Appendix C.

II. SITE DESCRIPTION

The 37,000 square foot West Side Learning Center consists of a single-story brick, mortar, cinderblock, and steel building with basement, constructed in 1987.

CERTIFIED reviewed floor plans supplied by City Colleges of Chicago during the inspection of this building. The building is presently being used as a school and consists of classrooms, mechanical areas, a main office, and a basement. Beige 12"x12" floor tile and 2'x4' suspended ceiling tile are prevalent throughout the building.

III. METHODOLOGY

A. Survey Approach

Suspect ACM was identified based on a complete building walk-through, documentation review and on-site interviews with building staff. The inspection included only those areas to which CERTIFIED was provided access and did not include areas access to which would have required damaging building components (such as hard enclosures).

Suspect materials were divided into "Homogeneous Applications," building materials which were determined by the inspector to be homogeneous based on their color, texture and age. Homogeneous applications were classified under the following categories: thermal system insulation (TSI), surfacing material (S), and miscellaneous material (M).

Using guidelines set forth in the Asbestos Hazard Emergency Response Act (AHERA), representative samples of each type of homogeneous material encountered were collected. With the exception of floor tile and suspect materials which were not accessible to sample, a minimum of three samples were collected for each Homogeneous Application. Furthermore, a minimum of five samples was collected of homogeneous surfacing material with an extent of 1,000 to 5,000 square feet. For homogeneous material over 5,000 square feet, at least seven samples were collected.

B. Assessment

CERTIFIED assessed the condition of asbestos-containing materials (ACM) in accordance with assessment criteria described in AHERA. See Appendix F for a description of AHERA assessment categories.

In general, assessment of material condition included, among other factors, area occupancy and use, existing damage and potential for damage. Determination of a material's potential for damage included evaluation of the building's airflow and occupancy, and the material's friability and susceptibility to water, vibration and/or mechanical damage.

C. Analytical Methods

Material identification was performed using Polarized Light Microscopy with Dispersion Staining (PLM/DS). Samples were analyzed by PLM/DS in accordance with the Environmental Protection Agency (EPA) "Interim Method for the Determination of Asbestos in Bulk Insulation Samples" (EPA-600-M4-82-020). Percentage estimates of each material's components are based on the analyst's best judgement following PLM/DS analysis and examination with a stereoscope. PLM/DS analysis was conducted at CERTIFIED's Weymouth, Massachusetts laboratory.

Samples of non-insulation materials which were found not to contain asbestos using optical microscopy were further analyzed by electron microscopy with sample preparation as specified in the "Chatfield Standard Operating Procedure" (proposed to ASTM Committee D22.05.07.007). Electron microscopy with sample preparation using the Chatfield Method is the state-of-the-art analytical technique for analysis of samples of materials other than friable insulation such as floor tile, plaster and textured ceiling material.

IV. FINDINGS AND RECOMMENDATIONS

This section provides a description of each confirmed ACM material application type present at West Side Learning Center as well as a section summarizing CERTIFIED's recommendations.

Asbestos-containing material in generally good condition was found throughout the West Side Learning Center. See Appendix F for a summary of possible response actions as defined under AHERA.

CONFIRMED ASBESTOS-CONTAINING MATERIALS

Asbestos-containing spray-on textured plaster (Homogeneous Area S-01) was found throughout the West Side Learning Center. The material is in good condition and should be maintained under the provisions of an O&M Program.

NON-ASBESTOS-CONTAINING MATERIALS

No asbestos was detected in the 2'x4' suspended ceiling tile (Homogeneous Area M-02) or 12"x12" beige floor tile (Homogeneous Area M-01) at the West Side Learning Center.

RECOMMENDATIONS

As noted above, the textured plaster, S-01 is in generally good condition. The material can be maintained under the provisions of an O&M Program. The purpose of an O&M Program is threefold: first, to clean up asbestos fibers which may have been released during prior disturbances; second, to prevent possible future fiber release by reducing disturbance; and third, to monitor the condition of asbestos-containing materials.

All removal of asbestos-containing material must be conducted by a fully licensed abatement contractor. Removal should be performed in accordance with a state-of-the-art removal specification and all contractor work should be monitored by a third-party consultant.

V. COST ESTIMATES

Cost estimates for West Side Learning Center are provided in two sections: comprehensive costs for implementation of the response actions recommended by CERTIFIED and total removal costs.

- A. The cost to implement a &M Program is typically \$7,500 - \$10,000.
- B. A cost estimate for total removal of confirmed ACM is provided in the following chart. Please note that these estimates do not include costs associated with specification preparation, abatement monitoring, or reinstallation.

Limitations - These cost estimates for total removal of all confirmed ACM are only estimates. It is difficult, if not impossible, to predict the bid ranges of qualified contractors. A qualified contractor's bid will be affected by a number of factors, including: the timing of the project (i.e. season of the year, duration of the project), the amount of work bid or the number of small projects integrated into one bid package, and mobilization or demobilization costs. A contractor's bid is also affected by the accessibility of the material to be removed and sufficient preparation for ease of access into the area.

TOTAL ESTIMATED REMOVAL COST
CONFIRMED ASBESTOS-CONTAINING MATERIALS

HA #	Description	Square/Linear Footage	Cost per Unit	Total Cost
S-01	Spray-on textured plaster	37,000 sq.ft.	\$30.00	<u>\$1,110,000</u>

TOTAL ESTIMATED REMOVAL COSTS: \$1,110,000

TABLE 1

Confirmed Asbestos-Containing Materials

<u>Homogeneous Application #</u>	<u>Description</u>	<u>Location</u>
S-01	Spray-on textured plaster	On decking through- out building

TABLE 2
Non-Asbestos-Containing Materials

<u>Homogeneous Application #</u>	<u>Description</u>	<u>Location</u>
M-01	12"x12" beige floor tile	Throughout building
M-02	2'x4' suspended ceiling tile	Throughout building

TABLE 3

Electron microscopy analysis results

<u>Homogeneous Application #</u>	<u>Description</u>	<u>Results</u>
M-01	12"x12" beige floor tile	<1% Asbestos detected
S-01	Spray-on textured plaster	5-10% Asbestos detected

APPENDIX A

Limitations and Service Constraints

LIMITATIONS AND SERVICE CONSTRAINTS

All professional opinions presented in this report are based on information made available to us either by review of data provided by others or data gathered by CERTIFIED personnel.

CERTIFIED affirms that data gathered and presented by CERTIFIED in this report was collected in an appropriate manner in accordance with generally accepted methods and practices. CERTIFIED cannot be responsible for decisions made solely on the basis of economic factors.

CERTIFIED is not responsible for analyzed quantities which fall below published standard method detection limits for the method employed. CERTIFIED cannot be responsible for decisions made solely on the basis of economic factors.

Conditions described in this report are as found at the time of investigation, unless otherwise stated.

CERTIFIED analyzed only the substances, conditions and locations described in the report at the time indicated. No inferences regarding other substances, conditions, location or time can be made unless specifically stated in this report.

This report is intended for the use listed in the section of this report described as the Introduction. The use of this report in any manner other than that listed in the Introduction requires the written consent of Certified Engineering and Testing Company, Inc. This report must be presented on its entirety.

APPENDIX B

Sample Analysis Results

CERTIFIED ENGINEERING & TESTING COMPANY, INC.

BULK SAMPLE SUMMARY

Project Number: C00022-006 Project Name: WEST SIDE LEARNING CENTER

Analyst: NOEL EVERET REID

Date Analyzed: 7/24/90

Homogeneous Application	Location	Analysis Results	Sample Number
M-02	2' X 4' SUSPENDED CEILING TILE SAMPLE WAS COLLECTED IN THE ENGINEER'S OFFICE	NO ASBESTOS DETECTED	85365
M-02	2' X 4' SUSPENDED CEILING TILE SAMPLE WAS COLLECTED IN THE ENGINEER'S OFFICE	NO ASBESTOS DETECTED	85366
M-02	2' X 4' SUSPENDED CEILING TILE SAMPLE WAS COLLECTED IN ROOM #116	NO ASBESTOS DETECTED	85367
M-02	2' X 4' SUSPENDED CEILING TILE SAMPLE WAS COLLECTED IN HALLWAY OUTSIDE OF ROOM #118	NO ASBESTOS DETECTED	85368
M-02	2' X 4' SUSPENDED CEILING TILE SAMPLE WAS COLLECTED IN ROOM #118	NO ASBESTOS DETECTED	85369

BULK SAMPLE SUMMARY

Project Number: C00022-006 Project Name: WEST SIDE LEARNING CENTER

Analyst: NOEL EVERET REID

Date Analyzed: 7/24/90

Homogeneous Application	Location	Analysis Results	Sample Number
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BOILER ROOM	5-10% TOTAL ASBESTOS DETECTED	85358
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BOILER ROOM	NOT ANALYZED	85359
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BOILER ROOM	NOT ANALYZED	85360
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BOILER ROOM	NOT ANALYZED	85361
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BASEMENT OUTSIDE OF ROOM B4	NOT ANALYZED	85362

BULK SAMPLE SUMMARY

Project Number: C00022-006 Project Name: WEST SIDE LEARNING CENTER

Analyst: NOEL EVERET REID

Date Analyzed: 7/24/90

Homogeneous Application	Location	Analysis Results	Sample Number
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BASEMENT OUTSIDE OF ROOM B4	NOT ANALYZED	85363
S-01	TEXTURED SPRAY-ON PLASTER SAMPLE WAS COLLECTED IN THE BASEMENT	NOT ANALYZED	85364

CERTIFIED ENGINEERING & TESTING COMPANY, INC.

BULK SAMPLE SUMMARY

Project Number: C00040

Project Name: CITY COLLEGES - EM ANALYSIS

Analyst:

Date Analyzed:

Homogeneous Application	Location	Analysis Results	Sample Number
S-01	TEXTURED SPRAY-ON PLASTER WEST SIDE LEARNING CENTER - BASEMENT- SAMPLE COLLECTED AT BASE OF NORTH SIDE STAIRS FROM CEILING	SENT FOR EM CONFIRMATION	101321
S-01	TEXTURED SPRAY-ON PLASTER WEST SIDE LEARNING CENTER - BASEMENT- SAMPLE COLLECTED AT BASE OF SOUTHEAST STAIRS FROM CEILING	SENT FOR EM CONFIRMATION	101322
S-01	TEXTURED SPRAY-ON PLASTER WEST SIDE LEARNING CENTER - BASEMENT- SAMPLE COLLECTED FROM CENTER OF BASEMENT FROM CEILING	SENT FOR EM CONFIRMATION	101323

Project Title: WEST SIDE LEARNING CENTER

Date Collected: 07/19/90

Date In Lab: 07/24/90

Sampling Technician: ROBERT GARRITY

Sample Number: 85358

Sample Description: TEXTURED SPRAY-ON PLASTER
Location: SAMPLE WAS COLLECTED IN THE BOILER ROOM

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: 5-10% TOTAL ASBESTOS DETECTED

EM Result
(If Applicable)

Sample Number: 85359

Sample Description: TEXTURED SPRAY-ON PLASTER
Location: SAMPLE WAS COLLECTED IN THE BOILER ROOM

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: NOT ANALYZED

EM Result
(If Applicable)

Sample Number: 85360

Sample Description: TEXTURED SPRAY-ON PLASTER
Location: SAMPLE WAS COLLECTED IN THE BOILER ROOM

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: NOT ANALYZED

EM Result
(If Applicable)

Sample Number: 85361

Sample Description: TEXTURED SPRAY-ON PLASTER
Location: SAMPLE WAS COLLECTED IN THE BOILER ROOM

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: NOT ANALYZED

EM Result
(If Applicable)

Project Title: WEST SIDE LEARNING CENTER

Date Collected: 07/19/90

Date In Lab: 07/24/90

Sampling Technician: ROBERT GARRITY

Sample Number: 85362

Sample Description: TEXTURED SPRAY-ON PLASTER

Location: SAMPLE WAS COLLECTED IN THE BASEMENT OUTSIDE OF ROOM B4

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: NOT ANALYZED

EM Result
(If Applicable)

Sample Number: 85363

Sample Description: TEXTURED SPRAY-ON PLASTER

Location: SAMPLE WAS COLLECTED IN THE BASEMENT OUTSIDE OF ROOM B4

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: NOT ANALYZED

EM Result
(If Applicable)

Sample Number: 85364

Sample Description: TEXTURED SPRAY-ON PLASTER

Location: SAMPLE WAS COLLECTED IN THE BASEMENT

Comments: WHITE, FRIABLE

Homogeneous Application: S-01

PLM/DS Result: NOT ANALYZED

EM Result
(If Applicable)

Sample Number: 85365

Sample Description: 2' X 4' SUSPENDED CEILING TILE

Location: SAMPLE WAS COLLECTED IN THE ENGINEER'S OFFICE

Comments: GRAY, FRIABLE

Homogeneous Application: M-02

PLM/DS Result: NO ASBESTOS DETECTED

EM Result
(If Applicable)

Project Title: WEST SIDE LEARNING CENTER

Date Collected: 07/19/90

Date In Lab: 07/24/90

Sampling Technician: ROBERT GARRITY

Sample Number: 85366

Sample Description: 2' X 4' SUSPENDED CEILING TILE

Location: SAMPLE WAS COLLECTED IN THE ENGINEER'S OFFICE

Comments: GRAY, FRIABLE

Homogeneous Application: M-02

PLM/DS Result:NO ASBESTOS DETECTED

EM Result
(If Applicable)

Sample Number: 85367

Sample Description: 2' X 4' SUSPENDED CEILING TILE

Location: SAMPLE WAS COLLECTED IN ROOM #116

Comments: GRAY, FRIABLE

Homogeneous Application: M-02

PLM/DS Result:NO ASBESTOS DETECTED

EM Result
(If Applicable)

Sample Number: 85368

Sample Description: 2' X 4' SUSPENDED CEILING TILE

Location: SAMPLE WAS COLLECTED IN HALLWAY OUTSIDE OF ROOM #118

Comments: GRAY, FRIABLE

Homogeneous Application: M-02

PLM/DS Result:NO ASBESTOS DETECTED

EM Result
(If Applicable)

Sample Number: 85369

Sample Description: 2' X 4' SUSPENDED CEILING TILE

Location: SAMPLE WAS COLLECTED IN ROOM #118

Comments: GRAY, FRIABLE

Homogeneous Application: M-02

PLM/DS Result:NO ASBESTOS DETECTED

EM Result
(If Applicable)

CERTIFIED ENGINEERING & TESTING COMPANY, INC.

FIELD SAMPLING SHEET

Project Number: C00040

Project Title: CITY COLLEGES - EM ANALYSIS

Date Collected: 10/12/90

Date In Lab: 10/15/90

Sampling Technician: FRANK RODRIGUES

Sample Number: 101321

Sample Description: TEXTURED SPRAY-ON PLASTER

Location: WEST SIDE LEARNING CENTER - BASEMENT- SAMPLE COLLECTED AT BASE
OF NORTH SIDE STAIRS FROM CEILING

Comments: THROUGHOUT ENTIRE BUILDING

Homogeneous Application: S-01

PLM/DS Result: SENT FOR EM CONFIRMATION

EM Result
(If Applicable) <1% DETECTED

Sample Number: 101322

Sample Description: TEXTURED SPRAY-ON PLASTER

Location: WEST SIDE LEARNING CENTER - BASEMENT- SAMPLE COLLECTED AT BASE
OF SOUTHEAST STAIRS FROM CEILING

Comments: FRIABLE

Homogeneous Application: S-01

PLM/DS Result: SENT FOR EM CONFIRMATION

EM Result
(If Applicable) <1% DETECTED

Sample Number: 101323

Sample Description: TEXTURED SPRAY-ON PLASTER

Location: WEST SIDE LEARNING CENTER - BASEMENT- SAMPLE COLLECTED FROM
CENTER OF BASEMENT FROM CEILING

Comments: FRIABLE

Homogeneous Application: S-01

PLM/DS Result: SENT FOR EM CONFIRMATION

EM Result
(If Applicable) <1% DETECTED

CERTIFIED is accredited by the National Laboratory Accreditation Program (NVLAP). NVLAP functions as an unbiased third party for the evaluation and recognition of technical performance. NVLAP accreditation signifies recognition of a testing laboratory's competence to perform specific test methods, in this case the analysis of material suspected of containing asbestos by the "Interim Method of the Analysis of Asbestos in Friable Bulk Insulation Samples." (40 CFR Ch. I (1-1-87 edition) Pt. 763, subpt. F App. A). Accreditation indicates that the laboratory's quality assurance program, staff qualifications, facilities, equipment, calibration procedures, records and test reports have all been evaluated and found to meet NVLAP criteria. Specific requirements of this program include the reporting of certain analytical data used to arrive at the reported finding of the analysis. This data is reported, as required, in the following Appendix.

Date Analyzed: 7/24/90

Analyst: NOEL EVERETT REID

Signature:

Noel Everett Reid

Sample Number: 85358

Sample Color	Texture/Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
W	F	Y	N	Y	CEL FG CHR	
<u>Layer 1</u>			<u>Layer 2</u>			
% Asbestos: 5-10%			% Asbestos:			TOTAL ACM IN SAMPLE 5-10% TOTAL ASBESTOS DETECTED
% Other Fibers:			% Other Fibers:			MATRIX MATERIAL(S):
						Layer 1: VERMICULITE
						Layer 2:

Lab Comments:

N Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation
 Y This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate.
 N It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy

Sample Number: 85359

Sample Color	Texture/Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
<u>Layer 1</u>			<u>Layer 2</u>			
% Asbestos:			% Asbestos:			TOTAL ACM IN SAMPLE NOT ANALYZED
% Other Fibers:			% Other Fibers:			MATRIX MATERIAL(S):
						Layer 1:
						Layer 2:

Lab Comments: NOT ANALYZED

Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation
 This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate.
 It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy

Sample Number: 85360

Sample Color	Texture/Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
<u>Layer 1</u>			<u>Layer 2</u>			
% Asbestos:			% Asbestos:			TOTAL ACM IN SAMPLE NOT ANALYZED
% Other Fibers:			% Other Fibers:			MATRIX MATERIAL(S):
						Layer 1:
						Layer 2:

Lab Comments: NOT ANALYZED

Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation
 This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate.
 It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy

Date Analyzed: 7/24/90

Analyst: NOEL EVERET REID

Signature: *Noel Everett Reid*

Sample Number: 85361

Sample Color	Texture/ Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
-----------------	-------------------------	------------------------	--------------------------------	--------------------	----------------------------------	----------------------------------

Layer 1

% Asbestos:

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NOT ANALYZED

MATRIX MATERIAL(S):

Layer 1:

Layer 2:

Lab Comments: NOT ANALYZED

Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation. This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate. It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy.

Sample Number: 85362

Sample Color	Texture/ Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
-----------------	-------------------------	------------------------	--------------------------------	--------------------	----------------------------------	----------------------------------

Layer 1

% Asbestos:

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NOT ANALYZED

MATRIX MATERIAL(S):

Layer 1:

Layer 2:

Lab Comments: NOT ANALYZED

Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation. This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate. It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy.

Sample Number: 85363

Sample Color	Texture/ Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
-----------------	-------------------------	------------------------	--------------------------------	--------------------	----------------------------------	----------------------------------

Layer 1

% Asbestos:

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NOT ANALYZED

MATRIX MATERIAL(S):

Layer 1:

Layer 2:

Lab Comments: NOT ANALYZED

Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation. This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate. It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy.

Date Analyzed: 7/24/90

Analyst: NOEL EVERETT REID

Signature: *Noel Everett Reid*

Sample Number: 85364

Sample Color	Texture/ Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
--------------	----------------------	---------------------	-----------------------------	-----------------	-------------------------------	-------------------------------

Layer 1

% Asbestos:

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NOT ANALYZED

MATRIX MATERIAL(S):

Layer 1:

Layer 2:

Lab Comments: NOT ANALYZED

Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation. This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate. It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy.

Sample Number: 85365

Sample Color	Texture/ Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
G/W	F	Y	N	Y	CEL FG	

Layer 1

% Asbestos: 0%

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NO ASBESTOS DETECTED

MATRIX MATERIAL(S):

Layer 1: POLYSTYRENE

Layer 2:

Lab Comments:

N Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation. Y This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate. N It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy.

Sample Number: 85366

Sample Color	Texture/ Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
W/G	F	Y	N	Y	CEL FG	

Layer 1

% Asbestos: 0%

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NO ASBESTOS DETECTED

MATRIX MATERIAL(S):

Layer 1: POLYSTYRENE

Layer 2:

Lab Comments:

N Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation. Y This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate. N It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy.

Date Analyzed: 7/24/90

Analyst: NOEL EVERET REID

Signature:

Noel Everett Reid

Sample Number: 85367

Sample Color	Texture/Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
G/W	F	Y	N	Y	CEL FG	

Layer 1

% Asbestos: 0%

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NO ASBESTOS DETECTED

MATRIX MATERIAL(S):

Layer 1: POLYSTYRENE

Layer 2:

Lab Comments:

N Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation
Y This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate.
N It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy

Sample Number: 85368

Sample Color	Texture/Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
W/G	F	Y	N	Y	CEL FG	

Layer 1

% Asbestos: 0%

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NO ASBESTOS DETECTED

MATRIX MATERIAL(S):

Layer 1: POLYSTYRENE

Layer 2:

Lab Comments:

N Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation
Y This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate.
N It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy

Sample Number: 85369

Sample Color	Texture/Composition	Homogeneous Sample?	Layers Analyzed Separately?	Fibers Present?	Fiber Identification Layer 1:	Fiber Identification Layer 2:
W/G	F	Y	N	Y	CEL FG	

Layer 1

% Asbestos: 0%

% Other Fibers:

Layer 2

% Asbestos:

% Other Fibers:

TOTAL ACM IN SAMPLE NO ASBESTOS DETECTED

MATRIX MATERIAL(S):

Layer 1: POLYSTYRENE

Layer 2:

Lab Comments:

N Analysis of this material meets the requirements of the Interim Method for the Analysis of Bulk Asbestos Insulation
Y This analysis is an exception to the Interim Method for the Analysis of Bulk Asbestos Insulation. However, it is the Analyst's professional opinion that the results are accurate.
N It is the professional opinion of the Analyst that this analysis should be confirmed by Electron Microscopy

APPENDIX C

List of Investigated Materials

CERTIFIED ENGINEERING AND TESTING COMPANY, INC.

ASBESTOS SURVEY
FIELD CHECKLIST
STANDARD FINANCIAL

I. MECHANICAL AND THERMAL INSULATION

A. Boilers and Heating Systems

1. Boilers
 - A. Jacket
 - B. Breeching (Flue or Exhaust Pipe)
2. Steam Lines with fittings, (e.g. elbows, tees, valves, etc.)
3. Condensate Return Lines with fittings, (e.g. elbows, tees, valves, etc.)
4. Fittings, (e.g. elbows, tees, valves, etc.) Without straight-runs of pipe, sample separately.
5. Reheat Unit (Typically above ceiling)
6. Floor Fan Housing
7. Flex Connectors (Vibration Isolation Cloth)
8. Tank Insulation
9. Duct Insulation
 - A. Inside
 - B. Outside
10. Heat Exchanger

B. HVAC Systems

1. Chiller Unit
2. Water Lines
3. Cooling Tower
4. Cooling Tower Packing

APPENDIX C

List of Investigated Materials

CERTIFIED ENGINEERING AND TESTING COMPANY, INC.

ASBESTOS SURVEY
FIELD CHECKLIST
STANDARD FINANCIAL

I. MECHANICAL AND THERMAL INSULATION

A. Boilers and Heating Systems

1. Boilers
 - A. Jacket
 - B. Breeching (Flue or Exhaust Pipe)
2. Steam Lines with fittings, (e.g. elbows, tees, valves, etc.)
3. Condensate Return Lines with fittings, (e.g. elbows, tees, valves, etc.)
4. Fittings, (e.g. elbows, tees, valves, etc.) Without straight-runs of pipe, sample separately.
5. Reheat Unit (Typically above ceiling)
6. Floor Fan Housing
7. Flex Connectors (Vibration Isolation Cloth)
8. Tank Insulation
9. Duct Insulation
 - A. Inside
 - B. Outside
10. Heat Exchanger

B. HVAC Systems

1. Chiller Unit
2. Water Lines
3. Cooling Tower
4. Cooling Tower Packing

CERTIFIED ENGINEERING AND TESTING COMPANY, INC.

ASBESTOS SURVEY
FIELD CHECKLIST
STANDARD FINANCIAL

C. Water Systems

1. Domestic Water Supply Lines
2. Drain Lines
 - A. Roof
 - B. Miscellaneous Equipment

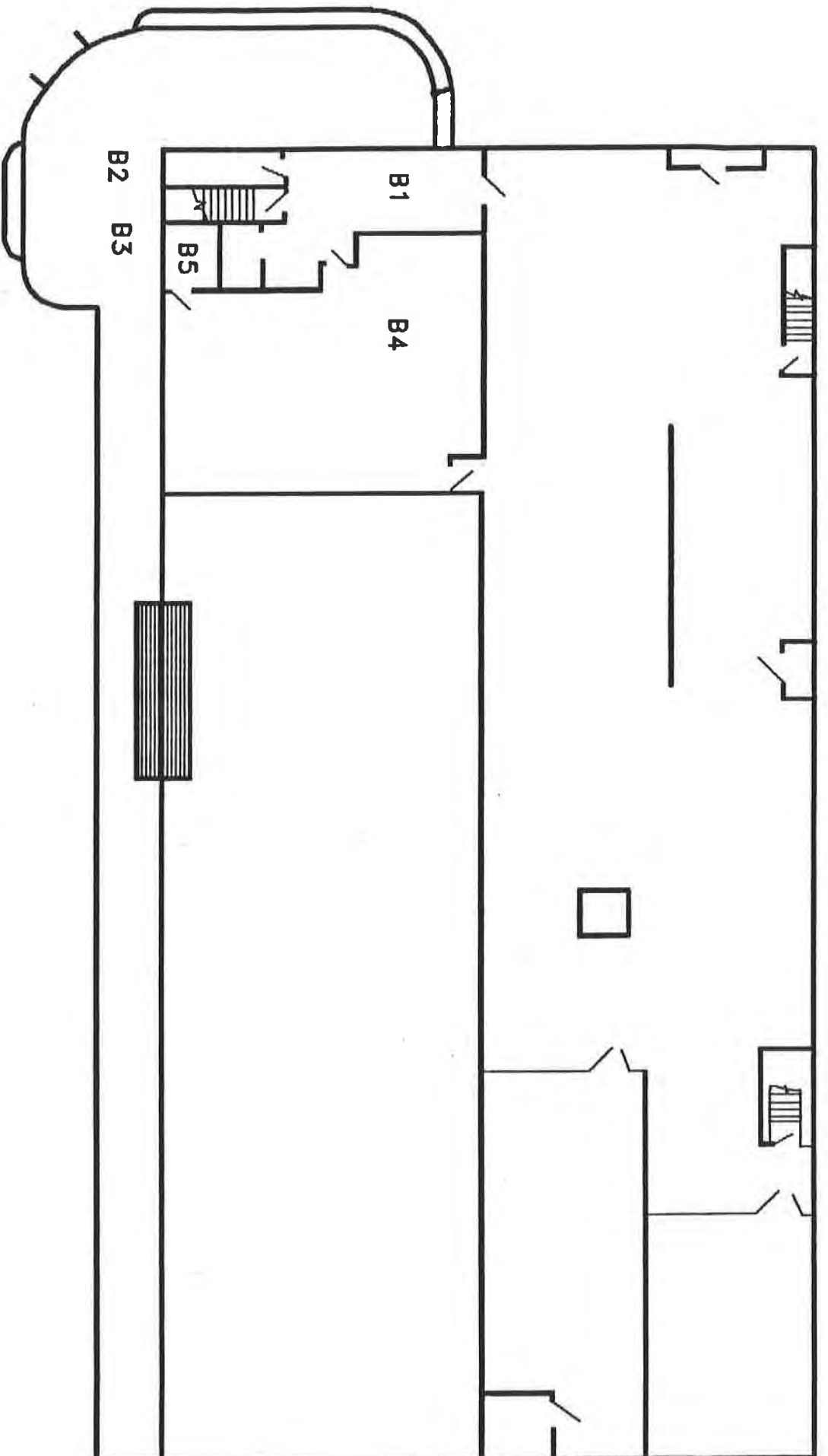
II. BUILDING MATERIAL

A. Inside

1. Spray-on Fireproofing
 - A. Deck
 - B. Structural Steel
 - C. Concrete
2. Textured Ceiling Material
3. Ceiling Tile
 - a. Lay-in
 - b. Spline
4. Plaster Ceiling Material
5. Spray Acoustical Ceiling
6. Textured Wall Material
7. Plaster Walls
8. Transite Walls
9. Wall Board

APPENDIX E

Floor Plans



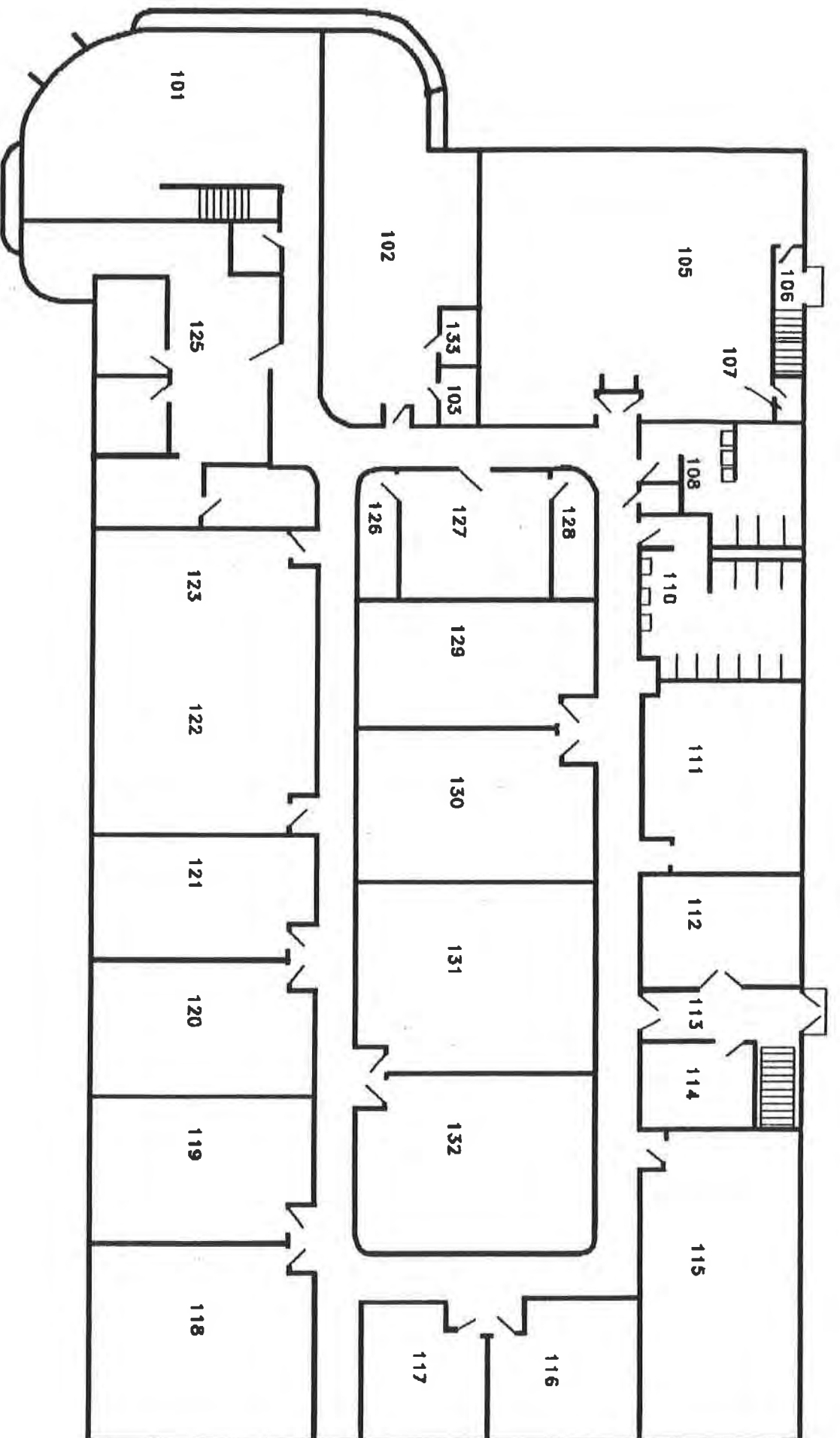
CERTIFIED ENGINEERING & TESTING CO., INC.
INDUSTRIAL HYGIENE DEPARTMENT
25 EAST WASHINGTON ST., SUITE 1500
CHICAGO, ILLINOIS 60602
TELEPHONE: 1-(312)-419-0197

NOTES: DRAWING NOT TO SCALE.
ALL LOCATIONS ARE APPROXIMATE.
DRAWING INTENDED FOR USE WITH
CERTIFIED REPORT ONLY.

BASEMENT
FLOOR



PROJECT NO: C00022-006
LOCATION: WEST SIDE LEARNING CTR.
4624 WEST MADISON ST.
CHICAGO, ILLINOIS



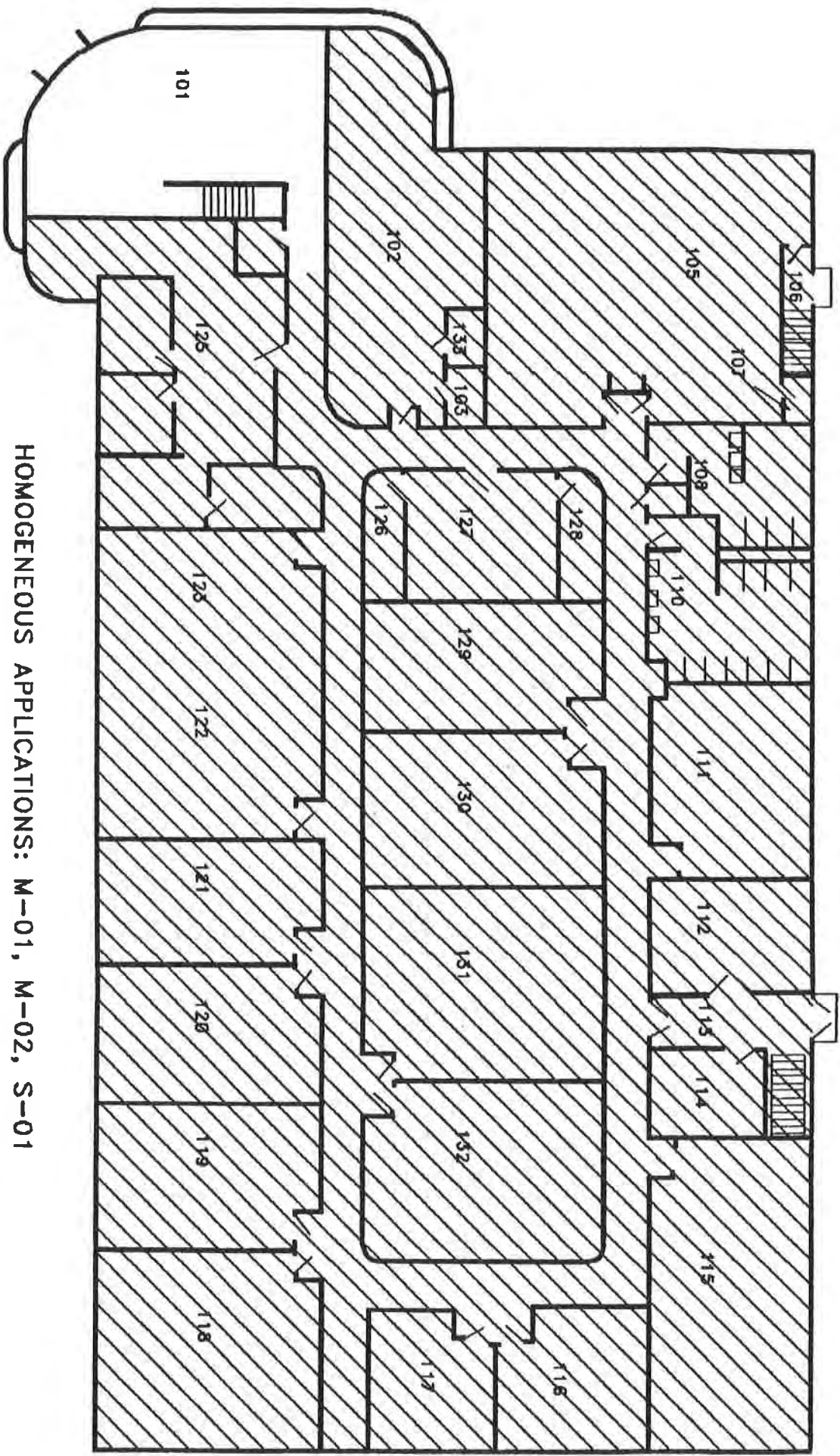
CERTIFIED ENGINEERING & TESTING CO., INC.
INDUSTRIAL HYGIENE DEPARTMENT
25 EAST WASHINGTON ST., SUITE 1500
CHICAGO, ILLINOIS 60602
TELEPHONE: 1-(312)-419-0197

NOTES: DRAWING NOT TO SCALE.
ALL LOCATIONS ARE APPROXIMATE.
DRAWING INTENDED FOR USE WITH
CERTIFIED REPORT ONLY.

GROUND
FLOOR



PROJECT NO: C00022-006
LOCATION: WEST SIDE LEARNING CTR.
4624 WEST MADISON ST.
CHICAGO, ILLINOIS



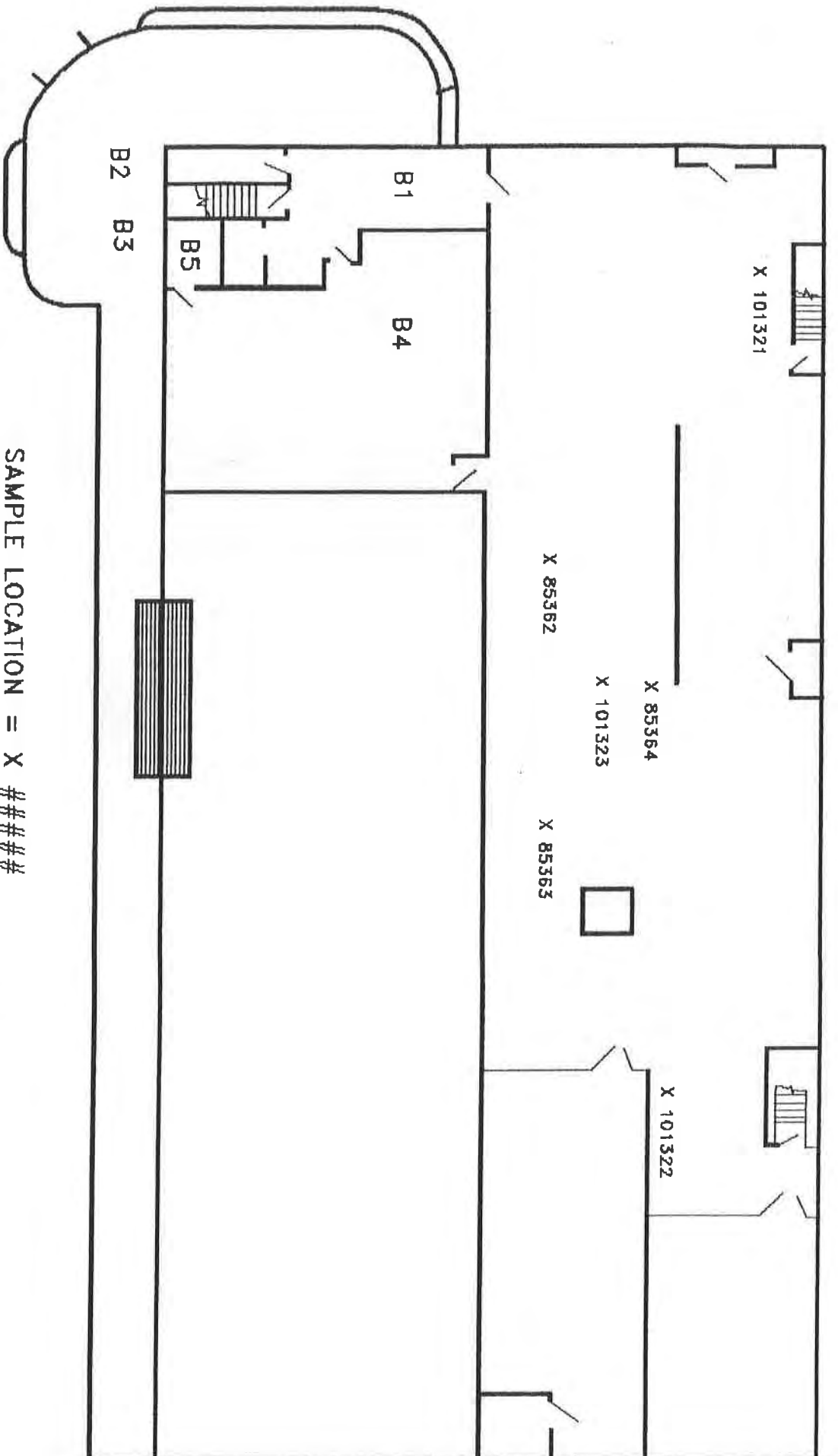
HOMOGENEOUS APPLICATIONS: M-01, M-02, S-01
(HATCHED AREA)

CERTIFIED ENGINEERING & TESTING CO., INC.
INDUSTRIAL HYGIENE DEPARTMENT
25 EAST WASHINGTON ST., SUITE 1500
CHICAGO, ILLINOIS 60602
TELEPHONE: 1-(312)-419-0197

NOTES: DRAWING NOT TO SCALE.
ALL LOCATIONS ARE APPROXIMATE.
DRAWING INTENDED FOR USE WITH
CERTIFIED REPORT ONLY.

GROUND
FLOOR

PROJECT NO: C00022-006
LOCATION: WEST SIDE LEARNING CTR.
4624 WEST MADISON ST.
CHICAGO, ILLINOIS



SAMPLE LOCATION = X #####

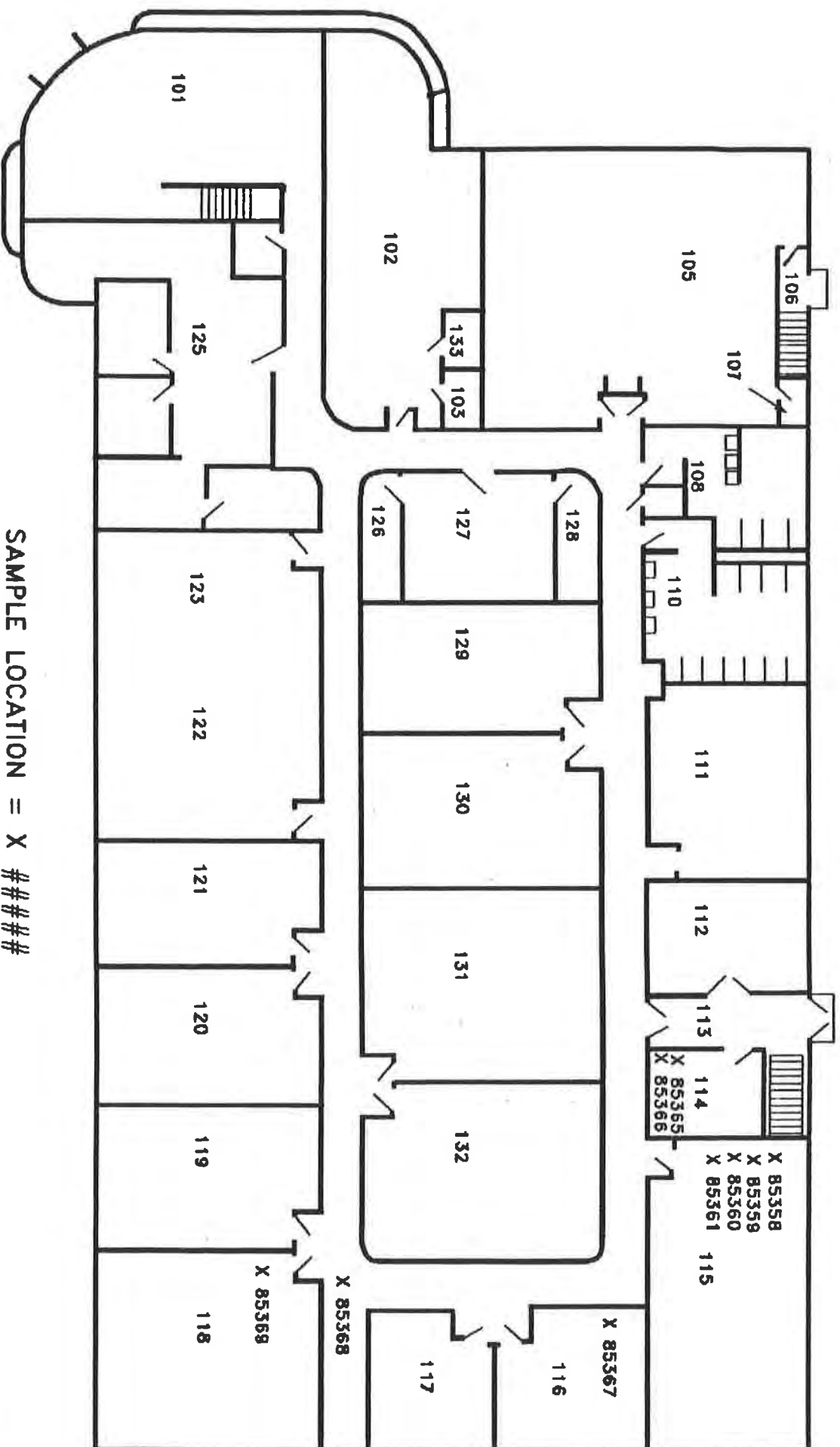
CERTIFIED ENGINEERING & TESTING CO., INC.
INDUSTRIAL HYGIENE DEPARTMENT
25 EAST WASHINGTON ST., SUITE 1500
CHICAGO, ILLINOIS 60602
TELEPHONE: 1-(312)-419-0197

NOTES: DRAWING NOT TO SCALE.
ALL LOCATIONS ARE APPROXIMATE.
DRAWING INTENDED FOR USE WITH
CERTIFIED REPORT ONLY.

BASEMENT
FLOOR



PROJECT NO: C00022-006
LOCATION: WEST SIDE LEARNING CTR.
4624 WEST MADISON ST.
CHICAGO, ILLINOIS



CERTIFIED ENGINEERING & TESTING CO., INC.
 INDUSTRIAL HYGIENE DEPARTMENT
 25 EAST WASHINGTON ST., SUITE 1500
 CHICAGO, ILLINOIS 60602
 TELEPHONE: 1-(312)-419-0197

NOTES: DRAWING NOT TO SCALE.
 ALL LOCATIONS ARE APPROXIMATE.
 DRAWING INTENDED FOR USE WITH
 CERTIFIED REPORT ONLY.

GROUND
 FLOOR



PROJECT NO: C00022-006
 LOCATION: WEST SIDE LEARNING CTR.
 4624 WEST MADISON ST.
 CHICAGO, ILLINOIS

APPENDIX F

AHERA Assessment Categories and Recommended Response Actions

Good Condition - ACM with no visible damage or deterioration, or showing only very limited damage or deterioration.

Damaged or significantly damaged thermal system insulation (TSI) - TSI ACM on pipes, boilers, tanks, ducts, and other TSI equipment where the insulation has lost its structural integrity, or its covering, in whole or in part, and is crushed, water stained, gouged, punctured, missing, or not intact such that it is not able to contain fibers.

Damaged friable surfacing ACM - friable surfacing ACM which has deteriorated or sustained physical injury such that the internal structure (cohesion) of the material is inadequate or which has delaminated such that its bond to the substrate (adhesion) is inadequate, or which, for any other reason, lacks fiber cohesion or adhesion qualities.

Significantly damaged friable surfacing ACM - damaged friable surfacing ACM in a functional space where damage is extensive and severe.

Damaged and significantly damaged friable miscellaneous ACM - damaged friable miscellaneous ACM where the damage is extensive and severe.

ACM with potential for damage - (1) friable ACM in an area regularly used by building occupants, including maintenance personnel in the course of their normal activities, and (2) ACM in locations in which there are indications that there is a reasonable likelihood that the material or its covering will become damaged, deteriorated, or delaminated due to factors such as changes in operations and maintenance practices, changes in occupancy, or recurrent damage.

ACM with potential for significant damage - (1) friable ACM in an area regularly used by building occupants, including maintenance personnel in the course of their normal activities; (2) ACM in locations in which there are indications that there is a reasonable likelihood that the material or its covering will become significantly damaged, deteriorated, or delaminated due to factors such as changes in building use, changes in operations and maintenance practices, changes in occupancy, or recurrent damage, and (3) ACM subject to major or continuing disturbance, due to factor including, but not limited to accessibility.

Recommended Response Actions

Immediate Removal: When a material poses an immediate threat to the health and safety of building occupants, CERTIFIED recommends Immediate Removal. Materials requiring immediate removal are generally highly damaged and routinely accessible to building occupants. It is often necessary to temporarily isolate the Immediate Removal area in accordance with the provisions of the Operations and Maintenance Program until such time as a licensed, qualified asbestos abatement contractor can perform the removal.

Removal When Practical: When a material is badly damaged, has the potential for damage or is highly accessible, particularly to students, CERTIFIED recommends Removal When Practical. Material recommended for Removal When Practical generally require careful maintenance under the Operations and Maintenance Program until such time as scheduling and budgeting considerations allow for their removal.

Patch and Repair: Materials which are damaged can often be repaired rather than removed. Patch and Repair activities can be undertaken, if less than three square feet of damage is involved, by properly trained in-house maintenance personnel. In some cases, temporary patch and repair of damaged materials is necessary pending removal to reduce their potential for fiber release.

Enclosure: Enclosure, isolation of a material behind a hard, airtight, impermeable barrier, is recommended by CERTIFIED only in very rare circumstances in which either the material cannot be removed or it is in a rarely accessed area where there is relative certainty that no renovations are likely to take place for the life of the building. Enclosure is not substantially less expensive than removal and is therefore recommended infrequently.

Encapsulation: Encapsulation, coating the material with a bonding or sealing agent, is generally recommended by CERTIFIED as an interim response pending removal of the material.

Operations and Maintenance Program (O&M): Maintenance of ACM under the Operations and Maintenance Program is recommended for all ACM at every college. The O&M Program, which provides guidelines for the day to day management and handling of ACM at Wright Junior College, must be implemented and employed whenever asbestos is present. Materials which are scheduled for abatement must be maintained under the O&M Program until such time as they are removed. Likewise, ACM which is to remain in the building must be maintained under the O&M for the duration.

Two types of O&M Programs are available. The first type of program, the "limited" O&M, provides guidelines for maintenance procedures which will not disturb low friable materials (i.e. floor tile and plaster) and prohibits maintenance personnel from performing such activities as abrasive buffing of the floor or removing tiles. Under this type of program, all removal and repair must be performed by an outside asbestos abatement contractor.

The second type of program, the "comprehensive" O&M, also includes guidelines for routine maintenance procedures, but, in addition includes training, equipment and procedures such that in-house personnel can do minor repair work and be involved in controlled disturbance of the materials.

Localized Damage Areas: In cases where there is localized damage within a homogeneous area, CERTIFIED may choose to define this specific area as a Localized Damage Area. Each such area is described in detail which also provides a separate response action and cost estimate.

APPENDIX G

ASBESTOS MANAGEMENT SCHEDULE

ASBESTOS MANAGEMENT SCHEDULE

A. Tentative Implementation Schedule

1. Choose Asbestos Coordinator.
2. Implement Operations and Maintenance Program
 - a. train all maintenance employees as required
 - b. begin patch and repair operations
 - c. determine approximate schedule for recommended removal
3. Prepare schedule for semi-annual ACM surveillance including re-inspection by an accredited Inspector every three years.
4. Begin contractor selection procedures if removal operations are recommended CERTIFIED

B. Operations and Maintenance Training

1. Two - Hour Awareness Training - provides an overview of the O&M document, focussing on the location, application type and condition of the ACM, health effects of asbestos, and precautionary procedures.
2. Two Day (14 hour) Training - provides greater detail concerning the O&M document and its usage, provides hands-on training on how to perform asbestos-related maintenance procedures, describes the health effects of asbestos, explains the regulations which pertain to asbestos in great detail, trains personnel on usage of asbestos abatement and maintenance equipment and includes respirator-fit testing for all appropriate personnel.

C. Operations and Maintenance Program Cost

Following implementation of the Operations and Maintenance Program and associated training, the annual cost of the Operations and Maintenance Program can vary widely depending on the amount of asbestos present, and on the extent of damage. The estimated cost to purchase the necessary equipment to implement an O&M program ranges from \$1,000.00 - \$3,000.00. This equipment may include the following:

ITEM

SUPPLIER

Respirators, PAPR Full Face

MSA
600 Penn Center Blvd.
Pittsburgh, PA 15235
1-800-MSA-2222

Disposable Clothing

Suits (XXXL)

Head Coverings

Booties

Bath Towels

6-mil "Asbestos" waste bags

6-mil black "plastic"

6-mil clear "plastic"

Duct Tape

Yellow Asbestos Warning Labels

Bonne Terre Industries
3080 McCall Drive #3
Atlanta, GA 30340
1-800-222-5252

or

Asbestos Control
Technology, Inc.
P.O. box 183
Maple Shade, NJ 08052
1-800-221-1911

or

Lyons Safety
1-800-221-1911

Vacuum with HEPA filter

Nilfisk
33566 N. Lake Shore Dr.
Gages Lake, IL 60030
708-223-6626

Emergency Decontamination
Chambers

(Spotshower)

Creative Innovations
P.O. Box 3257
Westchester, PA 19381
or

Fiberlock Tech, Inc.
P.O. Box 432
Cambridge, MA 02139-
0432

617-876-8020

ITEM

SUPPLIER

Ladders (sufficient height)
Pushcart (vinyl surface)
Flashlights (hard plastic cover)
Drums (55 gal. plastic or metal
to catch water)
Sponges
Pails
Utility Knives (retractable
blade)

Hardware Store