



PROJECT MANUAL

Volume II of II

Montgomery County Magistrate and Court Services Building

Christiansburg, Virginia

Prepared for
**Montgomery County Board of
Supervisors**

T&L Project No. 16910
Issued for Bid October 11, 2023



**THOMPSON
& LITTON** EST.
1936

PROJECT MANUAL

Montgomery County Magistrate and Court Services Building Christiansburg, Virginia

Prepared For Montgomery County Board of Supervisors

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of Thompson & Litton and is not to be used in whole or in part for any other project without the written authorization of Thompson & Litton.



THOMPSON & LITTON

**726 Auburn Avenue
Radford, Virginia 24141**

T&L Project No. 16910

Issued for Bid October 11, 2023

Montgomery County Magistrate and Court Services Building
Christiansburg, Virginia
For
Montgomery County Board of Supervisors

T&L Project No. 16910

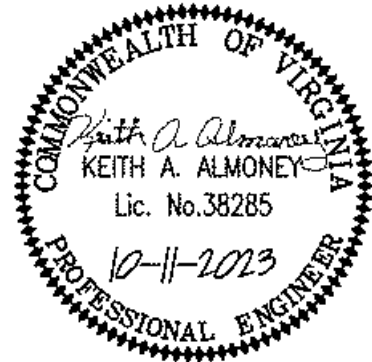
SEALS PAGE



For Architectural & Life Safety
Only



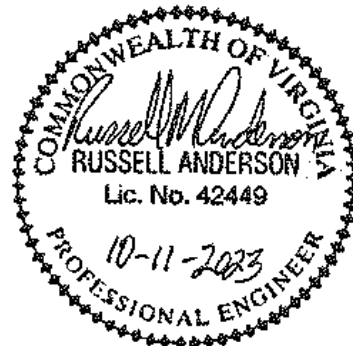
For Civil Engineering Only



For Structural Only



For Plumbing, Mechanical, & Fire
Protection Only



For Electrical Only

Montgomery County Magistrate and Court Services Building

T&L Project No. 16910

TABLE OF CONTENTS Volume I

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

00 0101	Project Title Page
00 0107	Seals Page
00 0110	Table of Contents
00 0115	Drawings Index
00 1113	Advertisement for Bids
00 2113	Instructions to Bidders
00 2515	Pre-Bid Question Form
00 3132	Geotechnical Data
00 4100	Bid Form
00 4313	Bid Bond (AIA A310)
00 4513	Contractor's Qualification Statement (AIA A305)
00 4546.13	Workers' Compensation Certificate (DGS 30-076)
00 4546.16	Certification of Bidder Regarding Debarment
00 5213	Standard Form of Agreement Between Owner & Contractor (AIA A101)
00 5213.10	Insurance and Bonds (AIA A101 - Exhibit A)
00 5433	Request for Electronic Files Form
00 6113	Performance Bond & Payment Bond (AIA A312)*
00 6275	Payment Application Checklist
00 6276	Application & Certificate for Payment (AIA G702)*
00 6276.10	Continuation Sheet (AIA G703)*
00 6276.11	Weather Delay Request
00 6313	Request for Information (RFI) Form
00 6325	Request for Substitution Form
00 6333	Architect's Supplemental Instructions (AIA G710)*
00 6346	Construction Change Directive (AIA G714)*
00 6353	Proposal Request (AIA G709)*
00 6363	Change Order (AIA G701)*
00 6516	Certificate of Substantial Completion (AIA G704)*
00 6519.13	Contractor's Affidavit of Payment of Debts & Claims (AIA G706)*
00 6519.16	Contractor's Affidavit of Release of Liens (AIA G706A)*
00 6519.19	Consent of Surety Company to Final Payment (AIA G707)*
00 7210	General Conditions of the Contract for Construction (AIA A201)
00 7310	Supplementary General Conditions

** Asterisks indicate references made to AIA (American Institute of Architects) documents - latest edition, which are hereby made a part of the Contract Documents. All provisions and requirements contained in reference, after being duly executed, shall be considered as part of the Contract Documents, as if bound herein. Copies of the referenced documents are available for review at the office of the Architect. Contractors shall purchase copies from the American Institute of Architects. The original document shall be provided by the Contractor and will be required for the execution of the "Contract".*

TABLE OF CONTENTS (CONTINUED)

SPECIFICATIONS

DIVISION 01 - GENERAL REQUIREMENTS

01 1000	Summary
01 2000	Price and Payment Procedures
01 2100	Allowances
01 2200	Unit Prices
01 3000	Administrative Requirements
01 4000	Quality Requirements
01 4533	Code-Required Special Inspections and Procedures
01 5000	Temporary Facilities and Controls
01 5100	Temporary Utilities
01 5213	Field Offices and Sheds
01 5500	Vehicular Access and Parking
01 6000	Product Requirements
01 7000	Execution And Closeout Requirements
01 7419	Construction Waste Management and Disposal
01 7800	Closeout Submittals
01 9113	General Commissioning Requirements
01 9114	Commissioning Authority Responsibilities

TABLE OF CONTENTS (CONTINUED)

DIVISION 02 - EXISTING CONDITIONS

02 4100 Demolition

DIVISION 03 - CONCRETE

03 3000 Cast-In-Place Concrete

03 4500 Precast Architectural Concrete

DIVISION 04 - MASONRY

04 2000 Unit Masonry

DIVISION 05 - METALS

05 1200 Structural Steel Framing

05 2100 Steel Joist Framing

05 3100 Steel Decking

05 4400 Cold-Formed Metal Trusses

05 5000 Metal Fabrications

05 5213 Pipe and Tube Railings

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

06 1000 Rough Carpentry

06 4100 Architectural Wood Casework

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07 2100 Thermal Insulation

07 2500 Weather Barriers

07 4113 Metal Roof Panels

TABLE OF CONTENTS (CONTINUED)

07 4213	Metal Wall Panels
07 4213.23	Metal Composite Material Wall Panels
07 5400	Thermoplastic Membrane Roofing
07 6200	Sheet Metal Flashing and Trim
07 7100	Roof Specialties
07 7200	Roof Accessories
07 8400	Firestopping
07 9200	Joint Sealants

DIVISION 08 - OPENINGS

08 1113	Hollow Metal Doors and Frames
08 1416	Flush Wood Doors
08 3100	Access Doors and Panels
08 3313	Coiling Counter Doors
08 3323	Overhead Coiling Doors
08 4313	Aluminum-Framed Storefronts
08 5653	Security Windows
08 7100	Door Hardware
08 8000	Glazing

DIVISION 09 - FINISHES

09 2116	Gypsum Board Assemblies
09 5100	Acoustical Ceilings

TABLE OF CONTENTS (CONTINUED)

09 6500	Resilient Flooring
09 6700	Fluid-Applied Flooring
09 6813	Tile Carpeting
09 9113	Exterior Painting
09 9123	Interior Painting

DIVISION 10 - SPECIALTIES

10 1400	Signage
10 1419	Dimensional Letter Signage
10 2800	Toilet, Bath, and Laundry Accessories
10 4400	Fire Protection Specialties

DIVISION 12 - FURNISHINGS

12 2400	Window Shades
12 3600	Countertops

TABLE OF CONTENTS (CONTINUED)

Montgomery County Magistrate and Court Services Building

T&L Project No. 16910

TABLE OF CONTENTS Volume II

DIVISION 21 - FIRE SUPPRESSION

21 0500	Common Work Results for Fire Suppression
21 1300	Fire-Suppression Sprinkler Systems

DIVISION 22 – PLUMBING

22 0529	Hangers And Supports for Plumbing Piping And Equipment
22 0553	Identification For Plumbing Piping and Equipment
22 0719	Plumbing Piping Insulation
22 1005	Plumbing Piping
22 1006	Plumbing Piping Specialties
22 3000	Plumbing Equipment
22 4000	Plumbing Fixtures

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

23 0529	Hangers And Supports for HVAC Piping And Equipment
23 0553	Identification For HVAC Piping and Equipment
23 0593	Testing, Adjusting, And Balancing for HVAC
23 0713	Duct Insulation
23 0900	Instrumentation And Control for HVAC
23 0910	Existing BAS Integration

TABLE OF CONTENTS (CONTINUED)

23 1123	Facility Natural-Gas Piping
23 3100	HVAC Ducts and Casings
23 3300	Air Duct Accessories
23 3423	HVAC Power Ventilators
23 3700	Air Outlets and Inlets
23 7416	Packaged Rooftop Air-Conditioning Units
23 8150	Ductless Split System Units
23 8200	Convection Heating and Cooling Units

DIVISION 26 - ELECTRICAL

26 0519	Low-Voltage Electrical Power Conductors and Cables
26 0526	Grounding And Bonding for Electrical Systems
26 0529	Hangers And Supports for Electrical Systems
26 0533.13	Conduit for Electrical Systems
26 0533.16	Boxes for Electrical Systems
26 0536	Cable Trays for Electrical Systems
26 0553	Identification for Electrical Systems
26 0583	Wiring Connections
26 0923	Lighting Control Devices
26 2416	Panelboards
26 2726	Wiring Devices
26 2813	Fuses

TABLE OF CONTENTS (CONTINUED)

26 2816.13 Enclosed Circuit Breakers

26 2816.16 Enclosed Switches

26 3213 Engine Generators

26 3600 Transfer Switches

26 5100 Interior Lighting

26 5600 Exterior Lighting

DIVISION 27 - COMMUNICATIONS

27 0529 Hangers And Supports for Communications Systems

27 1000 Structured Cabling

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

28 4600 Fire Detection and Alarm

DIVISION 31 - EARTHWORK

31 1000 Site Clearing

31 2200 Grading

31 2316 Excavation

31 2316.13 Trenching

31 2316.26 Rock Removal

31 2323 Fill

DIVISION 32 - EXTERIOR IMPROVEMENTS

32 1123 Aggregate Base Courses

32 1216 Asphalt Paving

TABLE OF CONTENTS (CONTINUED)

32 1723.13 Painted Pavement Markings

32 3113 Chain Link Fences and Gates

32 9219 Seeding

32 9223 Sodding

DIVISION 33 - UTILITIES

33 0132 Sewer and Manhole Testing

33 0513 Manholes and Structures

33 1116 Water Utility Distribution Piping

33 1300 Disinfecting Of Water Utility Distribution

33 3111 Sanitary Utility Sewerage Piping

33 4111 Storm Utility Drainage Piping

APPENDICES

Appendix A: Geotechnical Engineering Report, dated April 14, 2023 & Revised May 10, 2023

Appendix B: Asbestos & Lead Inspection Report, dated July 21, 2023

Appendix C: Duct Bank – Test Hole Inventory Report

**Montgomery County Magistrate and Court Services Building
Christiansburg, Virginia
For
Montgomery County Board of Supervisors**

T&L Project No. 16910

DRAWINGS INDEX

<u>DRAWING TITLE:</u>	<u>DRAWING NUMBER:</u>
General	
Title Sheet	G001
Project Data & Life Safety Plan	G002
Sallyport Code Information	G003
Proposed Phasing Plans	G004
Civil	
Town of Christiansburg Standard Cover	TC01
Town Of Christiansburg Standard Notes	TC02
Legend, General Notes, Erosion & Sediment Control Notes and Legend, and Parking Analysis	C001
Zoning Map	C100
Existing Site Plan	C101
Demolition Plan	C200
Site Plan	C300
Grading Plan	C301
Greenspace Requirements	C302
Utility Plan	C400
Erosion & Sediment Control Plan - Phase 1	C500
Erosion And Sediment Control Plan - Phase 2	C501
Profiles - Stormwater	C600
Profiles - Water and Sanitary Sewer	C601
Standard Sewer Details	C700
Standard Water Details	C701
Erosion & Sediment Control Details & Minimum Standards	C702
Miscellaneous Site Details – Erosion & Sediment Control Notes	C703
Stormwater Management Details	C704
Traffic & Pedestrian Management Plan	V100
Architectural	
Notes, Legends, Abbreviations, & Typical Details	A001
Architectural Site Plan	A002
Architectural Site Plan Details	A003

DRAWINGS INDEX (CONTINUED)

Overall Floor Plan	A101
Magistrate Enlarged Plan	A102
Court Services Enlarged Plan	A103
Overall Reflected Ceiling Plan	A104
Magistrate Enlarged Reflected Ceiling Plan	A105
Court Services Enlarged Reflected Ceiling Plan	A106
Overall Roof Plan	A107
Building Elevations	A201
Building Sections	A301
Wall Sections	A311
Wall Sections	A312
Wall Sections	A313
Section Details	A321
Details	A501
Interior Elevations and Details	A601
Interior Elevations and Details	A602
Finish Schedules, Notes, & Legend	A701
Signage Plan and Details	A702
Opening Schedule	A711
Storefront Details	A712
Structural	
General Notes, Design Criteria, Sections and Details	S001
Foundation/Slab Plan	S100
Roof Framing Plan	S101
Retaining Wall Foundation Plan	S102
Typical Details	S200
Typical Details	S201
Sections	S300
Sections	S301
Fire Protection	
Fire Protection Notes and Details	FP001
Plumbing	
Plumbing Notes, Schedules & Specification	P001
Plumbing Details	P002
Magistrates Office Building & Sallyport Waste and Vent	P101
Magistrates Office Building & Sallyport Water Supply	P102
Court Services Building Waste and Vent Piping	P103
Court Services Building Water Supply Piping	P104
Roof Drain Piping Plan	P105

DRAWINGS INDEX (CONTINUED)

Magistrates Office Building and Sallyport Piping Diagrams	P106
Mechanical	
HVAC Legends, Notes & Schedules	M001
HVAC Details	M002
HVAC Controls	M003
HVAC Controls	M004
HVAC Controls	M005
HVAC Controls	M006
Magistrate's Office & Sallyport - HVAC Plan	M101
Court Services - HVAC Plan	M102
HVAC Roof Plan	M103
Gas Piping Plans	M104
Electrical	
Electrical Notes, Legend, and Abbreviations	E001
Electrical Site Plan	ES01
Site Lighting Photometrics	ES02
Lighting Plan	E101
Power Plan	E201
Communications Plan	E301
Electrical Details	E501
Electrical One - Line Diagram and Schedules	E601
Electrical Schedules	E602
Electrical Schedules	E603

SECTION 21 0500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe, fittings, sleeves, escutcheons, seals, and connections for sprinkler systems.

1.2 REFERENCE STANDARDS

- A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250 2020.
- B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- C. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250 2021.
- D. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings 1999, with Editorial Revision (2022).
- E. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- F. ASTM A536 - Standard Specification for Ductile Iron Castings 1984, with Editorial Revision (2019).
- G. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems 2023a.
- H. NFPA 13 - Standard for the Installation of Sprinkler Systems Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.3 SUBMITTALS

- A. Product Data: Provide manufacturers catalogue information. Indicate valve data and ratings.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 PRODUCTS

2.1 FIRE PROTECTION SYSTEMS

- A. Sprinkler Systems: Comply with NFPA 13.

2.2 ABOVE GROUND PIPING

- A. Steel Pipe: ASTM A795 Schedule 10 or _____, black.
 - 1. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings and ASME B16.4, threaded fittings.
 - 2. Malleable Iron Fittings: ASME B16.3, threaded fittings and ASTM A47/A47M.
 - 3. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.
 - 4. Mechanical Formed Fittings: Carbon steel housing with integral pipe stop and O-ring pocked and O-ring, uniformly compressed into permanent mechanical engagement onto pipe.
- B. Ductile Iron Pipe: AWWA C151/A21.51.
 - 1. Fittings: AWWA C110/A21.10, standard thickness.
 - 2. Joints: AWWA C111/A21.11, SBR or vulcanized styrene butadiene rubber gasket.
 - 3. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped composition sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

2.3 PIPE SLEEVES

- A. Vertical Piping:
 - 1. Sleeve Length: 1 inch above finished floor.
 - 2. Provide sealant for watertight joint.
- B. Plastic, Sheet Metal, or Moisture-Resistant Fiber: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.

2.4 FIRE-RATED ENCLOSURES

- A. Provide as required to preserve fire resistance rating of building elements.

2.5 ESCUTCHEONS

- A. Material:
 - 1. Metals and Finish: Comply with ASME A112.18.1.

2.6 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.

- B. Hangers for Pipe Sizes 2 inches and Over: Carbon steel, adjustable, clevis.
- C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- D. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.
- E. Wall Support for Pipe Sizes 4 inches and Over: Welded steel bracket and wrought steel clamp.
- F. Vertical Support: Steel riser clamp.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Install sprinkler system and service main piping, hangers, and supports in accordance with NFPA 13.
- B. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- C. Install piping to conserve building space, to not interfere with use of space and other work.
- D. Group piping whenever practical at common elevations.
- E. Pipe Hangers and Supports:
 - 1. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 2. Place hangers within 12 inches of each horizontal elbow.
 - 3. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 4. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 5. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- F. Escutcheons:
 - 1. Install and firmly attach escutcheons at piping penetrations into finished spaces.

2. Provide escutcheons on both sides of partitions separating finished areas through which piping passes.
3. Use chrome plated escutcheons in occupied spaces and to conceal openings in construction.

3.3 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION

SECTION 21 1300 - FIRE-SUPPRESSION SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Wet-pipe sprinkler system.
- B. Dry-pipe sprinkler system.
- C. System design, installation, and certification.

1.2 REFERENCE STANDARDS

- A. NFPA 13 - Standard for the Installation of Sprinkler Systems Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.3 SUBMITTALS

- A. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- B. Shop Drawings:
 - 1. Submit preliminary layout of finished ceiling areas indicating only sprinkler locations coordinated with ceiling installation.
 - 2. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Sprinklers: Type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
 - 2. Sprinkler Wrenches: For each sprinkler type.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

PART 2 PRODUCTS

2.1 SPRINKLER SYSTEM

- A. Sprinkler System: Provide coverage for entire building.
- B. Occupancy: Ordinary hazard, Group 1; comply with NFPA 13.
- C. Water Supply: Determine volume and pressure from water flow test data.

- D. Storage Cabinet for Spare Sprinklers and Tools: Steel, located adjacent to alarm valve.

2.2 SPRINKLERS

- A. Suspended Ceiling Type: Semi-recessed pendant type with matching push on escutcheon plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- B. Exposed Area Type: Pendant type with guard.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- C. Dry Sprinklers: Concealed pendant type with matching push on escutcheon plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: Brass.
 - 4. Cover Plate Finish: Brass.
 - 5. Fusible Link: Fusible solder link type temperature rated for specific area hazard.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with referenced NFPA design and installation standard.
- B. Install equipment in accordance with manufacturer's instructions.
- C. Extend existing sprinkler system into expanded Sally Port. Confirm existing conditions.
- D. Place pipe runs to minimize obstruction to other work.
- E. Place piping in concealed spaces above finished ceilings.
- F. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.
- G. Flush piping system of foreign matter.

- H. Hydrostatically test entire system.
- I. Require test be witnessed by Fire Marshal or local AHJ.

3.2 INTERFACE WITH OTHER PRODUCTS

- A. Ensure required devices are installed and connected as required to fire alarm system.

END OF SECTION

This page intentionally left blank

SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe hangers.
- B. Pipe supports, guides, shields, and saddles.

1.2 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping 2023.
- C. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- D. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures 1999 (Reapproved 2022).
- E. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2023.
- F. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength 2023.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2023b.
- H. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- I. UL (DIR) - Online Certifications Directory Current Edition.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.

3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Provide required hardware to hang or support piping, equipment, or fixtures with related accessories as necessary to complete installation of plumbing work.
- B. Provide hardware products listed, classified, and labeled as suitable for intended purpose.
- C. Corrosion Resistance: Use corrosion-resistant metal-based materials fully compatible with exposed piping materials and suitable for the environment where installed.

2.2 PIPE HANGERS

- A. Band Hangers, Adjustable:
 1. MSS SP-58 type 7 or 9, zinc-plated ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
- B. J-Hangers, Adjustable:
 1. MSS SP-58 type 5, zinc-plated ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
- C. Swivel Ring Hangers, Adjustable:
 1. MSS SP-58 type 10, epoxy-painted, zinc-colored.
 2. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
- D. Clevis Hangers, Adjustable:
 1. Copper Tube: MSS SP-58 type 1, epoxy-plated copper.
 2. Light-Duty: MSS SP-58 type 1, zinc-colored, epoxy plated.
 3. Standard-Duty: MSS SP-58 type 1, zinc-colored, epoxy plated.

2.3 PIPE CLAMPS

- A. Riser Clamps:

1. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
2. MSS SP-58 type 1 or 8, carbon steel or steel with epoxy plated, plain, stainless steel, or zinc plated finish.
3. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.

2.4 PIPE SUPPORTS, GUIDES, SHIELDS, AND SADDLES

- A. Dielectric Barriers: Provide between metallic supports and metallic piping and associated items of dissimilar type; acceptable dielectric barriers include rubber or plastic sheets or coatings attached securely to pipe or item.
- B. Stanchions:
 1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
 3. For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.
- C. U-Bolts:
 1. MSS SP-58 type 24, carbon steel u-bolt for pipe support or anchoring.
- D. Pipe Shields for Insulated Piping:
 1. MSS SP-58 type 40, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
 2. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Service Temperature: Minus 40 to 178 degrees F.
 - e. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- E. Pipe Supports:
 1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
 2. Liquid Temperatures Up to 122 degrees F:

- a. Overhead Support: MSS SP-58 types 1, 3 through 12 clamps.
- b. Support From Below: MSS SP-58 types 35 through 38.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- C. Unless specifically indicated or approved by Architect/Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- D. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- E. Remove temporary supports.

3.3 FIELD QUALITY CONTROL

- A. Inspect support and attachment components for damage and defects.
- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Stencils.
- D. Ceiling tacks.

1.2 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A. Piping: Tags.
- B. Pumps: Nameplates.
- C. Valves: Tags and ceiling tacks where located above lay-in ceiling.

2.2 NAMEPLATES

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

2.3 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- C. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.4 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:

1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.

2.5 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.
- B. Color code as follows:
 1. Plumbing Valves: Green.

PART 3 EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

SECTION 22 0719 - PLUMBING PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Piping insulation.

1.2 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019, with Editorial Revision (2023).
- B. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2023.
- C. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation 2022.
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2023b.
- E. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials 2022a, with Editorial Revision (2023).
- F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.3 SUBMITTALS

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

1.4 DELIVERY, STORAGE, AND HANDLING

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

1.5 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.1 GLASS FIBER

- A. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 850 degrees F.

3. Maximum Moisture Absorption: 0.2 percent by volume.

2.2 CELLULAR GLASS

- A. Insulation: ASTM C552, Type II, Grade 6.
 1. K Value: 0.35 at 100 degrees F.
 2. Service Temperature Range: From 250 degrees F to 800 degrees F.
 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
 4. Water Absorption: 0.5 percent by volume, maximum.

2.3 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
 1. Minimum Service Temperature: Minus 40 degrees F.
 2. Maximum Service Temperature: 220 degrees F.
 3. Connection: Waterproof vapor barrier adhesive.

2.4 JACKETS

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

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Exposed Piping: Locate insulation and cover seams in least visible locations.
- C. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion

joints.

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

END OF SECTION

This page intentionally left blank

SECTION 22 1005 - PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe, pipe fittings, specialties, and connections for piping systems.
 - 1. Sanitary sewer.
 - 2. Domestic water.
 - 3. Flanges, unions, and couplings.
 - 4. Valves.
 - 5. Water pressure reducing valves.

1.2 REFERENCE STANDARDS

- A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- B. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250 2021.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2021.
- E. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings: DWV 2021.
- F. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes 2018.
- G. ASME B31.9 - Building Services Piping 2020.
- H. ASSE 1003 - Water Pressure Reducing Valves for Potable Water Distribution Systems 2023.
- I. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings 2021.
- J. ASTM B32 - Standard Specification for Solder Metal 2020.
- K. ASTM B42 - Standard Specification for Seamless Copper Pipe, Standard Sizes 2020.
- L. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2022.
- M. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- N. ASTM B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube 2016.
- O. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings 2016.
- P. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings 2020a.

- Q. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120 2021a.
- R. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems 2020.
- S. ASTM D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings 2020.
- T. ASTM D2729 - Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings 2021.
- U. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets 2020.
- V. ASTM D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings 2021.
- W. AWWA C550 - Protective Interior Coatings for Valves and Hydrants 2017.
- X. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- Y. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- Z. NSF 372 - Drinking Water System Components - Lead Content 2022.

1.3 SUBMITTALS

- A. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.4 QUALITY ASSURANCE

- A. Perform work in accordance with applicable codes.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Potable Water Supply Systems: Provide piping, pipe fittings, and solder and flux (if used), that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

2.2 SANITARY SEWER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 extra heavy weight.
 - 1. Fittings: Cast iron.
 - 2. Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets or lead and oakum.
- B. PVC Pipe: ASTM D2665 or ASTM D3034.
 - 1. Fittings: PVC.
 - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

2.3 SANITARY SEWER PIPING, ABOVE GRADE

- A. Cast Iron Pipe: ASTM A74, service weight.
 - 1. Fittings: Cast iron.
 - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.
- B. PVC Pipe: ASTM D2729.
 - 1. Fittings: PVC.
 - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

2.4 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Copper Pipe: ASTM B42, hard drawn.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22 wrought copper and bronze.
 - 2. Joints: ASTM B32, alloy Sn95 solder.
 - 3. Joints: AWS A5.8M/A5.8, BCuP copper/silver braze.

2.5 DOMESTIC WATER PIPING, ABOVE GRADE

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), Drawn (H).
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Fittings: Cast iron, coated.
 - 3. Joints: ASTM B32, alloy Sn95 solder.

2.6 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: Threaded or welded to ASME B31.1.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) or L (B) annealed.
 - 1. Fittings: ASME B16.26, cast bronze.
 - 2. Joints: Flared.

2.7 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:
 - 1. Ferrous pipe: Class 150 malleable iron threaded unions.
 - 2. Copper tube and pipe: Class 150 bronze unions with soldered joints.
- B. Flanges for Pipe Size Over 1 Inch:
 - 1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
 - 2. Copper Tube and Pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.

2.8 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 - 2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
 - 3. Trapeze Hangers: Welded steel channel frames attached to structure.
 - 4. Vertical Pipe Support: Steel riser clamp.

2.9 BALL VALVES

- A. Construction, 4 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze or ductile iron body, 304 stainless steel or chrome plated brass ball, regular port, teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded or grooved ends with union.

2.10 BUTTERFLY VALVES

- A. Construction 1-1/2 Inches and Larger: MSS SP-67, 200 psi CWP, cast or ductile iron body, nickel-plated ductile iron disc, resilient replaceable EPDM seat, wafer ends, extended neck, 10

position lever handle.

2.11 WATER PRESSURE REDUCING VALVES

A. Up to 2 Inches:

1. ASSE 1003, bronze body, stainless steel, and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single union ends.

B. Over 2 Inches:

1. ASSE 1003, cast iron body with interior lining complying with AWWA C550, bronze fitted, elastomeric diaphragm and seat disc, flanged.

2.12 RELIEF VALVES

A. Pressure:

1. ANSI Z21.22, AGA certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

B. Temperature and Pressure:

1. ANSI Z21.22, AGA certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F, capacity ASME BPVC-IV certified and labelled.

PART 3 EXECUTION

3.1 EXAMINATION

- #### **A. Verify that excavations are to required grade, dry, and not over-excavated.**

3.2 PREPARATION

- #### **A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.**
- #### **B. Remove scale and dirt, on inside and outside, before assembly.**
- #### **C. Prepare piping connections to equipment with flanges or unions.**

3.3 INSTALLATION

- #### **A. Install in accordance with manufacturer's instructions.**
- #### **B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.**
- #### **C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.**
- #### **D. Install piping to maintain headroom, conserve space, and not interfere with use of space.**
- #### **E. Group piping whenever practical at common elevations.**

- F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed.
- H. Copper Pipe and Tube: Make soldered joints in accordance with ASTM B828, using specified solder, and flux meeting ASTM B813; in potable water systems use flux also complying with NSF 61 and NSF 372.
- I. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.

3.4 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, verify system is complete, flushed and clean.
- B. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
- C. Maintain disinfectant in system for 24 hours.

END OF SECTION

SECTION 22 1006 - PLUMBING PIPING SPECIALTIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Drains.
- B. Cleanouts.
- C. Hose bibbs.
- D. Backflow preventers.
- E. Water hammer arrestors.
- F. Mixing valves.

1.2 REFERENCE STANDARDS

- A. ASME A112.6.3 - Floor and Trench Drains 2019.
- B. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- C. NSF 372 - Drinking Water System Components - Lead Content 2022.
- D. PDI-WH 201 - Water Hammer Arresters 2017.

1.3 SUBMITTALS

- A. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- B. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Accept specialties on site in original factory packaging. Inspect for damage.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Specialties in Potable Water Supply Systems: Provide products that comply with NSF 61 and NSF 372 for maximum lead content.

2.2 DRAINS

- A. Roof Drains:
 - 1. Assembly: ASME A112.6.4.
 - 2. Body: Lacquered cast iron with sump.
 - 3. Strainer: Removable polyethylene dome with vandal proof screws.

B. Floor Drains:

C. Floor Drain:

1. ASME A112.6.3; lacquered cast iron or stainless steel, two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable nickel-bronze strainer.

2.3 CLEANOUTS

A. Cleanouts at Exterior Surfaced Areas:

1. Round cast nickel bronze access frame and non-skid cover.

B. Cleanouts at Interior Finished Floor Areas:

1. Lacquered cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored cover in service areas and round gasketed depressed cover to accept floor finish in finished floor areas.

C. Cleanouts at Interior Finished Wall Areas :

1. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.

2.4 HOSE BIBBS

A. Interior Hose Bibbs:

1. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose thread spout, chrome plated where exposed with handwheel, integral vacuum breaker in compliance with ASSE 1011.

2.5 BACKFLOW PREVENTERS

A. Reduced Pressure Backflow Preventers:

1. ASSE 1013; bronze body with bronze internal parts and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve that opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

2.6 WATER HAMMER ARRESTORS

A. Water Hammer Arrestors:

1. Stainless steel construction, bellows type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range minus 100 to 300 degrees F and maximum 250 psi working pressure.

2.7 MIXING VALVES

A. Thermostatic Mixing Valves:

1. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- C. Encase exterior cleanouts in concrete flush with grade.
- D. Pipe relief from backflow preventer to nearest drain.

END OF SECTION

This page intentionally left blank

SECTION 22 3000 - PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Water Heaters:
 - 1. Commercial gas fired.
- B. In-line circulator pumps.

1.2 SUBMITTALS

- A. Product Data:
 - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. Indicate pump type, capacity, power requirements.
 - 3. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
 - 4. Provide electrical characteristics and connection requirements.

1.3 QUALITY ASSURANCE

- A. Certifications:
 - 1. Water Heaters: NSF approved.
 - 2. Gas Water Heaters: Certified by CSA International to ANSI Z21.10.1, as applicable, in addition to requirements specified elsewhere.
- B. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

PART 2 PRODUCTS

2.1 WATER HEATERS

- A. Commercial Gas Fired:
 - 1. Type: Automatic, natural gas-fired, tankless.
 - 2. Accessories:
 - a. Water Connections: Brass.
 - b. Dip Tube: Brass.
 - c. Drain valve.

- d. Anode: Magnesium.
 - e. Temperature and Pressure Relief Valve: ASME labeled.
3. Controls: Automatic water thermostat with temperature range adjustable from 120 to 180 degrees F, automatic reset high temperature limiting thermostat factory set at 195 degrees F, gas pressure regulator, multi-ribbon or tubular burner, 100 percent safety shut-off pilot and thermocouple, flue baffle and draft hood.

2.2 IN-LINE CIRCULATOR PUMPS

- A. Casing: Bronze, rated for 125 psig working pressure, with stainless steel rotor assembly.
- B. Impeller: Bronze.
- C. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.
- D. Seal: Carbon rotating against a stationary ceramic seat.
- E. Drive: Flexible coupling.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certification, if any.
- B. Coordinate with plumbing piping and related fuel piping work to achieve operating system.

END OF SECTION

SECTION 22 4000 - PLUMBING FIXTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Water closets.
- B. Urinals.
- C. Lavatories.
- D. Sinks.
- E. Under-lavatory pipe supply covers.
- F. Electric water coolers.
- G. Showers.

1.2 REFERENCE STANDARDS

- A. ADA Standards - 2010 ADA Standards for Accessible Design 2010.
- B. ASME A112.18.9 - Protectors/Insulators for Exposed Waste and Supplies on Accessible Fixtures 2011 (Reaffirmed 2022).
- C. ASHRAE Std 18 - Methods of Testing for Rating Drinking-Water Coolers with Self-Contained Mechanical Refrigeration 2008 (Reaffirmed 2013).
- D. ASME A112.6.1M - Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use 1997 (Reaffirmed 2017).
- E. ASME A112.18.1 - Plumbing Supply Fittings 2018, with Errata.
- F. ASME A112.19.3 - Stainless Steel Plumbing Fixtures 2022.
- G. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices 2020.
- H. ICC A117.1 - Accessible and Usable Buildings and Facilities 2017.
- I. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- J. NSF 372 - Drinking Water System Components - Lead Content 2022.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Potable Water Systems: Provide plumbing fittings and faucets that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

2.2 FLUSH VALVE WATER CLOSETS

- A. Water Closets: Vitreous china, ASME A112.19.2, floor mounted, siphon jet flush action, china bolt caps.
 - 1. Bowl: ASME A112.19.2; 16.5 inches high with elongated rim.
 - 2. Flush Valve: Exposed (top spud).
 - 3. Flush Operation: Manual, oscillating handle.
 - 4. Handle Height: 44 inches or less.
 - 5. Outlet Size: 2 inches.
 - 6. Color: White.
- B. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.
 - 1. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.

2.3 WALL HUNG URINALS

- A. Urinals: Vitreous china, ASME A112.19.2, wall hung with side shields and concealed carrier.
 - 1. Flush Volume: 1.0 gallons, maximum.
 - 2. Flush Valve: Exposed (top spud).
 - 3. Flush Operation: Manual, oscillating handle.
 - 4. Trap: Integral.
- B. Flush Valves: ASME A112.18.1, diaphragm type, complete with vacuum breaker stops and accessories.
 - 1. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.
- C. Carriers:
 - 1. ASME A112.6.1M; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded fixture studs for fixture hanger, bearing studs.

2.4 LAVATORIES

- A. Vitreous China Wall Hung Basin: ASME A112.19.2; vitreous china wall hung lavatory, minimum, with 4 inch high back, rectangular basin with splash lip, front overflow, and soap

depression.

1. Drilling Centers: 4 inch.
- B. Vitreous China Counter Top Basin: ASME A112.19.2; vitreous china self-rimming counter top lavatory, with drillings on 4 inch centers, front overflow, soap depression, seal of putty, calking, or concealed vinyl gasket.
- C. Vitreous China Under-Mount Basin: ASME A112.19.2; vitreous china under-mount lavatory, front overflow, mounting kit and template by manufacturer.
- D. Supply Faucet: ASME A112.18.1; chrome plated combination supply fitting with pop-up waste, water economy aerator with maximum flow of 2.2 gallons per minute, indexed handles.
- E. Thermostatic Mixing Valve: Thermostatic mixing valve, ASSE 1070 listed, with combination stop, strainer, and check valves, and flexible stainless steel connectors.

2.5 SINKS

- A. Single Compartment Bowl: ASME A112.19.3; outside dimensions 20 gage, 0.0359 inch thick, Type 302 stainless steel, self rimming and undercoated, with ledge back drilled for trim.
- B. Double Compartment Bowl: ASME A112.19.3; outside dimensions 20 gage, 0.0359 inch thick, Type 302 stainless steel, self rimming and undercoated, with ledge back drilled for trim.

2.6 UNDER-LAVATORY PIPE SUPPLY COVERS

- A. General:
 1. Insulate exposed drainage piping including hot, cold and tempered water supplies under lavatories or sinks per ADA Standards.
 2. Adhesives, sewing threads and two ply laminated materials are prohibited.
 3. Exterior Surfaces: Smooth nonabsorbent with no finger recessed indentations for easy cleaning.
 4. Construction: 1/8 inch PVC with antimicrobial, antifungal and UV resistant properties.
 - a. Comply with ASME A112.18.9 for covers on accessible lavatory piping.
 - b. Comply with ICC A117.1.

2.7 SHOWERS

- A. Cabinet: IAPMO Z124 reinforced glass fiber, with stone texture, integral receptor, soap dish, integral seat, removable chrome plated strainer, tail piece, .
- B. Trim: ASME A112.18.1; concealed shower supply with indexed handles, bent shower arm with adjustable spray ball joint showerhead with maximum 2.5 gallons per minute flow, and escutcheon.

- C. Shower Valve:
 - 1. Comply with ASME A112.18.1.
 - 2. Provide two handle in wall diverter valve body with integral thermostatic mixing valve to supply 1.5 gpm.
- D. Shower Head:
 - 1. ASME A112.18.1; chrome plated vandal-proof institutional head with integral wall bracket, built-in 2.5 gpm flow control.
- E. Thermostatic Mixing Valve: Thermostatic mixing valve, ASSE 1070 listed, with combination stop, strainer, and check valves, and flexible stainless steel connectors.

2.8 ELECTRIC WATER COOLERS

- A. Water Cooler: Electric, mechanically refrigerated; surface handicapped mounted; stainless steel top, vinyl on steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button, mounting bracket; integral air cooled condenser and stainless steel grille.
 - 1. Capacity: 8 gallons per hour of 50 degrees F water with inlet at 80 degrees F and room temperature of 90 degrees F, when tested in accordance with ASHRAE Std 18.
 - 2. Electrical: 115 V, 60 Hertz compressor, 6 foot cord and plug for connection to electric wiring system including grounding connector.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.
- C. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

3.2 INSTALLATION

- A. Install each fixture with trap, easily removable for servicing and cleaning.
- B. Provide chrome plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.
- C. Install components level and plumb.

3.3 INTERFACE WITH WORK OF OTHER SECTIONS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.4 ADJUSTING

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.5 CLEANING

- A. Clean plumbing fixtures and equipment.

3.6 PROTECTION

- A. Protect installed products from damage due to subsequent construction operations.
- B. Do not permit use of fixtures by construction personnel.
- C. Repair or replace damaged products before Date of Substantial Completion.

END OF SECTION

This page intentionally left blank

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Support and attachment components for equipment, piping, and other HVAC/hydraulic work.

1.2 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, non-penetrating rooftop supports, and thermal insulated pipe supports.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.

1.4 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Comply with MSS SP-58.
2. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
3. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 2. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
6. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.

1. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
2. Comply with MFMA-4.
3. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
4. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch.
5. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.

- C. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- D. Unless specifically indicated or approved by Architect/Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect/Engineer, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
 - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
- H. Secure fasteners according to manufacturer's recommended torque settings.
- I. Remove temporary supports.

3.3 FIELD QUALITY CONTROL

- A. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- B. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Adhesive-backed duct markers.
- D. Ceiling tacks.

1.2 RELATED REQUIREMENTS

- A. Section 09 9123 - Interior Painting: Identification painting.

1.3 REFERENCE STANDARDS

- A. ASTM D709 - Standard Specification for Laminated Thermosetting Materials 2017.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Product Data: Provide manufacturers catalog literature for each product required.
- D. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- E. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. VAV Boxes: Ceiling tacks, where located above lay-in ceiling.
- F. Ductwork: Nameplates.

2.2 NAMEPLATES

- A. Letter Color: White.
- B. Letter Height: 1/4 inch.
- C. Background Color: Black.
- D. Plastic: Comply with ASTM D709.

2.3 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

2.4 ADHESIVE-BACKED DUCT MARKERS

- A. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.
- B. Style: Individual Label.
- C. Color: Yellow/Black.

2.5 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.
- B. Color code as follows:
 - 1. HVAC Equipment: Yellow.
 - 2. Fire Dampers and Smoke Dampers: Red.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 9123 for stencil painting.

3.2 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of

structure or enclosure, and at each obstruction.

- D. Locate ceiling tacks to locate equipment or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

This page intentionally left blank

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 REFERENCE STANDARDS

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition 2016.
- B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems 2008, with Errata (2019).
- C. NEBB (TAB) - Procedural Standard for Testing Adjusting and Balancing of Environmental Systems 2019.
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing 2002.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Include at least the following in the plan:
 - a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - c. Identification and types of measurement instruments to be used and their most recent calibration date.
 - d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - e. Final test report forms to be used.
 - f. Procedures for formal deficiency reports, including scope, frequency and distribution.
- C. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
 - 1. Revise TAB plan to reflect actual procedures and submit as part of final report.

2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.
3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
4. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
5. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 1. AABC (NSTSB), AABC National Standards for Total System Balance.
 2. SMACNA (TAB).
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 2. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Systems are started and operating in a safe and normal condition.
 2. Temperature control systems are installed complete and operable.
 3. Proper thermal overload protection is in place for electrical equipment.
 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 5. Duct systems are clean of debris.
 6. Fans are rotating correctly.
 7. Fire and volume dampers are in place and open.
 8. Air coil fins are cleaned and combed.
 9. Access doors are closed and duct end caps are in place.
 10. Air outlets are installed and connected.
 11. Duct system leakage is minimized.
 12. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

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

3.4 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.5 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.
- M. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.
- N. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.
- O. On fan powered VAV boxes, adjust air flow switches for proper operation.

END OF SECTION

SECTION 23 0713 - DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Duct insulation.
- B. Duct liner.

1.2 REFERENCE STANDARDS

- A. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications 2013 (Reapproved 2019).
- B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2023b.
- D. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.6 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

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

2.2 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. 'K' value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 1200 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.

2.3 GLASS FIBER, RIGID

- A. Insulation: ASTM C612; rigid, noncombustible blanket.
 - 1. 'K' Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent.
 - 4. Maximum Density: 8.0 lb/cu ft.

2.4 DUCT LINER

- A. Note: Choose the liner type - Elastomeric Foam or Glass Fiber.

END OF SECTION

SECTION 23 0900 - INSTRUMENTATION AND CONTROL FOR HVAC

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 GENERAL

2.1 SECTION INCLUDES

- A. BUILDING AUTOMATION SYSTEM - GENERAL DESCRIPTION
- B. APPROVED CONTROL SYSTEM MANUFACTURES
- C. QUALITY ASSURANCE
- D. CODES AND STANDARDS
- E. SYSTEM PERFORMANCE
- F. SUBMITTAL REQUIREMENTS
- G. WARRANTY REQUIREMENTS
- H. SYSTEM MAINTENANCE AND REMOTE ANALYSIS
- I. OWNERSHIP OF PROPRIETARY MATERIAL
- J. DEFINITIONS

BUILDING AUTOMATION SYSTEM - GENERAL DESCRIPTION

- A. Provide a new Building Automation System (BAS) to integrate and control all mechanical equipment associated with this project. System shall also communicate with the existing county-wide Trane Connect System.
 - 1. The Building Automation System shall be as indicated on the drawings and described in these specifications. System must be fully integrated and coordinated with mechanical equipment DDC controllers furnished and installed in the equipment manufacturer's factory as specified in those sections. The intent of the BAS is to integrate all mechanical equipment into one system for global monitoring, control, and alarming associated with the building. It is the BAS manufacturer's responsibility to provide all the design, engineering, and field coordination required to ensure all equipment sequence of operations are met as specified and the designated BAS operators have the capability of managing the building mechanical system to ensure occupant comfort while maintaining energy efficiency.
 - 2. The BAS shall meet open standard protocol communication standards (As defined in System Communications Section) to ensure the system maintains "interoperability" to avoid proprietary arrangements that will make it difficult for the Owner to consider other BAS manufacturers in future projects.

3. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems and terminal devices on this project.
4. The BAS shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by the security permissions of the operator role. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the control system and have access to all appropriate data.

APPROVED CONTROL SYSTEM MANUFACTURES

A. Approved BAS Manufacturers

1. Trane Tracer®. No substitutions

QUALITY ASSURANCE

A. BAS Manufacturer Qualifications

1. The BAS manufacturer shall have an established business office within 50.00 miles of the project site and must provide 24 hours/day, 7 days/week response in the event of a customer warranty or service call.
2. The BAS Manufacturer shall have factory trained and certified personnel providing all engineering, service, startup, and commissioning field labor for the project from their local office location. BAS manufacturer shall be able to provide training certifications for all local office personnel upon request.
3. The BAS shall be provided by a single manufacturer and this manufacturer's equipment must consist of operator workstation software, Web-based hardware/software, Open Standard Protocol hardware/software, Custom application Programming Language, Graphical Programming Language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, actuators, etc.) need not be manufactured by the BAS manufacturer listed in this specification.
4. Independent representatives of BAS manufacturers are not acceptable. BAS vendor must be corporate owned entity of BAS manufacturer.

CODES AND STANDARDS

- ##### **A. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.**
1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
 2. National Electrical Code -- NFPA 70.
 3. Federal Communications Commission -- Part J.

4. ASHRAE/ANSI 135-2012 (BACnet) - (System Level Devices) - Building Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.
5. ASHRAE/ANSI 135-2012 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

SYSTEM PERFORMANCE

- A. Performance Standards. The BAS system shall conform to the following:
 1. Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 10 seconds of the operator's request.
 2. Graphic Refresh. The system shall update all dynamic points with current data within 10 seconds.
 3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 5 seconds. Analog objects shall start to adjust within 5 seconds.
 4. Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current within the prior 10 seconds.
 5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 10 seconds.
 6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
 7. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
 8. Multiple Alarm Annunciations. All workstations on the network shall receive alarms within 5 seconds of each other.
 9. Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.

SUBMITTAL REQUIREMENTS

- A. BAS manufacturer shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software being provided for this project. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications.

1. Provide three (3) printed copies of submittal package for review and approval.
- B. Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the BAS manufacturer of furnishing quantities required based upon contract documents.
- C. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.
- D. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats once they have been approved and as-built drawings have been completed.
- E. Submit the following within 90 days of contract award:
 1. A complete bill of materials of equipment to be used indicating quantities, manufacturers and model numbers.
 2. A schedule of all control valves including the valve size, pressure drop, model number (including pattern and connections), flow, CV, body pressure rating, and location.
 3. A schedule of all control dampers including damper size, pressure drop, manufacturer, and model number.
 4. Provide all manufacturers' technical cut sheets for major system components. When technical cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Include:
 - a. Building Controllers
 - b. Custom Application Controllers
 - c. Application Specific Controllers
 - d. Operator Workstations
 - e. Portable Operator Terminals
 - f. Auxiliary Control Devices
 5. Provide proposed Building Automation System architectural diagram depicting various controller types, workstations, device locations, addresses, and communication cable requirements
 6. Provide detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls provided by mechanical equipment manufacturers. Terminal numbers shall be clearly labeled.
 7. Provide a sequence of operation for each controlled mechanical system and terminal end devices.

8. Provide a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet system level device (i.e. Building Controller & Operator Workstations) type. This defines the points list for proper coordination of interoperability with other building systems if applicable for this project.
- F. Project Record Documents: Upon completion of installation, submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:
1. Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .dwg and .pdf drawing files shall be provided.
 2. Testing and Commissioning Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BAS) commissioning personnel.
 3. Operating and Maintenance (O & M) Manuals - These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:
 - a. Procedures for operating the BAS including logging on/off, alarm management, generation of reports, trends, overrides of computer control, modification of setpoints, and other interactive system requirements.
 - b. Explanation of how to design and install new points, new DDC controllers, and other BAS hardware.
 - c. Documentation, installation, and maintenance information for all third party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.
 - d. Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
 - e. Licenses, Guarantee, and Warranty documents for all equipment and systems.
- G. Training Manuals: The BAS manufacturer shall provide a course outline and copies of training manuals at least two weeks prior to the start of any corporate training class to be attended by the Owner.

WARRANTY REQUIREMENTS

- A. Warrant all work as follows:
1. BAS system labor and materials shall be warranted free from defects for a period of twelve (12) 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. 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. To ensure that the owner will have the most current operating system provided by the manufacturer, the BAS manufacturer shall include licensing and labor costs to facilitate software/firmware updates throughout the warranty period at no charge to the owner. These updates shall include upgrades for functional enhancements associated with the following: operator workstation software, project specific software, graphics, database, firmware updates, and all security related service packs. 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, upgrades, and training schedules for a one year period of time correlating with the warranty period.

SYSTEM MAINTENANCE AND REMOTE ANALYSIS

- A. The BAS Manufacture shall provide Building Automation System remote support and system analysis for a period of 1 year (beginning the date of substantial completion).
- B. The BAS manufacturer shall setup a secure remote connection for data collection, analytics and remote technical support for the HVAC systems included in this contract.
 1. Provide technician support during the warranty period to diagnose issues remotely through the secure remote connection.
 2. The building owner is responsible for providing adequate internet access.
- C. Connectivity / Remote Access / Network Security
 1. Provide and maintain secure remote access to the facilities Building Automation System (BAS) or other building systems. Users accessing service through this connection shall not have access to the building owners network. Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".
 2. Secure remote access to the BAS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone)
 3. The Owner will provide up to Three (3) IP drops and IP addresses on the owners network to gain access to the internet. The BAS manufacture shall coordinate with the Owners IT team, verify the proposed system shall meet all network security requirements and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. It shall be the responsibility of the BAS manufacture to coordinate with the owner for network connectivity.
- D. The BAS Manufacture shall provide a professional analysis for the facility HVAC systems.

1. The analysis shall consist of an evaluation of HVAC systems including charts and graphs which indicate both current building performance and opportunities for building and HVAC system performance improvement.
- E. The following shall be provided after substantial completion of the project:
1. Orientation meeting with the building owner's representative to identify the HVAC systems that will be evaluated.
 2. System setup for data collection and analytics. BAS Manufacture to setup a secure remote data collection and analytics for identified systems.
 3. Assessment analysis shall be performed by trained personnel with relevant professional credentials in HVAC systems, energy management and building optimization methodologies.
 4. Consultation meeting with owner to review performance reports and improvement opportunities.
- F. Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of owner.

OWNERSHIP OF PROPRIETARY MATERIAL

- A. Project specific software and documentation shall become the owner's property upon project completion. This includes the following:
1. Operator Graphic files
 2. As-built hardware design drawings
 3. Operating & Maintenance Manuals
 4. BAS System software database

DEFINITIONS

- A. DDC: Direct digital control
- B. I/O: Input/output.
- C. MS/TP: Manager Subordinate / Token Passing.
- D. POT: Portable Operator's Terminal.
- E. PID: Proportional plus integral plus derivative.
- F. RTD: Resistance temperature detector.
- G. BAS/ATC: Building Automation System/Automatic Temperature Controls.

PART 2 PRODUCTS

13.1 SECTION INCLUDES

- A. MATERIALS:
- B. SYSTEM COMMUNICATION
- C. OPERATOR INTERFACE
- D. BUILDING CONTROLLER SOFTWARE
- E. BUILDING / SYSTEM CONTROLLERS
- F. ADVANCED APPLICATION CONTROLLERS:
- G. APPLICATION SPECIFIC CONTROLLERS:
- H. APPLICATION CONTROLLER for Packaged Rooftop Units
- I. VARIABLE AIR VOLUME TERMINAL UNIT CONTROLLERS
- J. INPUT/OUTPUT INTERFACE:
- K. POWER SUPPLIES:
- L. AUXILIARY CONTROL DEVICES:
- M. WIRING AND RACEWAYS:

MATERIALS:

- A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Do not use this installation as a product test site unless explicitly approved in writing by the owner or the owner's representative. Spare parts shall be available for at least five years after completion of this contract.

SYSTEM COMMUNICATION

- A. System Communications
 - 1. Each workstation, building controller, and equipment controller communication interface shall utilize the BACnet™ protocol with an Ethernet (IEEE 802.3), Wi-Fi (IEEE 802.11), RS485 (EIA-485), or Zigbee® (802.15.4) physical interface and an appropriate data link technology as defined in ANSI®/ASHRAE® Standard 135-2012. (e.g. BACnet over IP, BACnet over IPv6, BACnet SC, BACnet over MS/TP, BACnet Zigbee).
 - 2. All system controllers shall be BTL listed as a BACnet Building Controller (B-BC) as defined in ANSI®/ASHRAE® Standard 135-2012.
 - 3. All documented status and control points, schedule, alarm, and data-log services or objects shall be available as standard object types as defined in ANSI®/ASHRAE® Standard 135-2012.

4. Each System Controller shall communicate with a network of Custom Application and Application Specific Controllers utilizing one or more of the interfaces documented within Field Bus Communications below.
5. All Operator Workstations (B-OWS, B-AWS) and Building Controllers (B-BC) shall support BACnet Secure Connect (BACnet SC), a secure and encrypted datalink layer specifically designed for those networks.

B. Field Bus Communications

1. BACnet™
 - a. All equipment and plant controllers shall be BTL listed as a BACnet Application Specific Controller (B-ASC) or a BACnet Advanced Application Controller (B-AAC) as defined in ANSI®/ASHRAE® Standard 135-2012.
 - b. All communication shall conform to ANSI®/ASHRAE® Standard 135-2012.
 - c. System Controller shall function as a BACnet router to each unit controller providing a globally unique BACnet Device ID for all BACnet controllers within the system.
 - d. BACnet Zigbee®
 - 1) Communication between System Controller and equipment/plant controllers shall utilize BACnet Zigbee as defined in ANSI®/ASHRAE® Standard 135-2012.
 - 2) Each equipment controller wireless communication interface shall self-heal to maintain operation in the event of network communication failure.
 - 3) Each zone sensor wireless communication interface shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications. Sensing options shall include temperature, relative humidity, CO2, and occupancy.
 - e. BACnet MS/TP
 - 1) Communication between System Controller and equipment/plant controllers shall utilize BACnet MS/TP as defined in ANSI®/ASHRAE® Standard 135-2012.

C. Variable Refrigerant Flow (VRF) Communications

1. The VRF system shall communicate with the BAS using one of the following communications methods.
 - a. The VRF system and the BAS shall utilize ANSI®/ASHRAE® Standard 135 (BACnet) protocol revision 12 or greater.
 - b. Recognizing that VRF manufacturers utilize proprietary protocols to pass information between VRF equipment components. A gateway device is an accepted method to convert proprietary data to BACnet data. BACnet data shall conform to BACnet protocol revision 12 or greater.

- c. When a device is capable of data exchange with the BACnet protocol across non-IP network segments, the BACnet protocol shall be used to exchange data. If a device does not support the BACnet protocol an alternative protocol may be used. Data exchanged using the alternative protocol shall be converted to the BACnet protocol to allow integration to the BAS.
- 2. To promote BAS interoperability, each instance of the following VRF system components shall be visible to the BAS network as a virtual BACnet device.
 - a. Indoor equipment
 - b. Outdoor equipment
 - c. Refrigerant manifold devices
 - d. Outdoor air ventilation systems
- 3. Virtual BACnet device functionality shall conform to BACnet protocol revision 12 or greater and meet the minimum functionality defined by BACnet device profile B-ASC.
- 4. The VRF indoor equipment shall support wireless zone sensors. Sensing options shall include temperature, relative humidity, CO2, and occupancy. Each zone sensor wireless communication interface shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.

OPERATOR INTERFACE

- A. Provide Building Operator Web Interface
 - 1. Manufacturer shall provide a user interface with time-of-day schedules, data collection, dashboards, reports and building summary, system applications, and self-expiring timed overrides. Manufacturer shall provide a published user and applications guide(s) that detail the system application operation, configuration, setup and troubleshooting.
 - 2. The building operator web interface shall be accessible via a web browser without requiring any "plug-ins" (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
 - 3. User Roles
 - a. The system shall include pre-defined "roles" that allow a system administrator to quickly assign permissions to a user.
 - b. User logon/logoff attempts shall be recorded.
 - c. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
 - 4. 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. On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.
5. Equipment and Application Pages
- a. The building operator web interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
 - 1) Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:
 - (a) Each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These graphics shall show all points dynamically as specified in the points list.
 - (b) Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.
 - 2) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
 - 3) Historical Data (As defined in Trend Logs section of CONTROLLER SOFTWARE) for the equipment or application without requiring a user to navigate to a Data Log page and perform a filter.
 - b. VAV Air System. An operator shall be able to view and control (where applicable) the following parameters via the building operator web interface:
 - 1) System Mode
 - 2) System Occupancy
 - 3) Ventilation (Outdoor air flow) setpoint
 - 4) Ventilation (Outdoor air flow) status
 - 5) Air Handler Static pressure setpoint
 - 6) Air Handler Static pressure status
 - 7) Air Handler occupancy status
 - 8) Air Handler Supply air cooling and heating set points
 - 9) Air Handler minimum, maximum and nominal static pressure setpoints
 - 10) VAV box minimum and maximum flow
 - 11) VAV box drive open and close overrides

- 12) VAV box occupancy status
 - 13) VAV box Airflow to space
 - 14) Average space temperature
 - 15) Minimum space temperature
 - 16) Maximum space temperature
6. System Graphics. Building operator web interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
- a. Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
 - b. Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
 - c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
7. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.
8. 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 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. Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
 - d. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
9. Scheduling. - The scheduling application shall provide graphical representation of the day, week, month and exception events.
10. Alarm/Event Notification

- a. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any building operator web 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) The operator shall be able to acknowledge and add comments to alarms
 - 3) Alarm/event messages shall use full language, easily recognized descriptors.
 - b. Alarm Suppression. Alarms shall be able to be suppressed based on load/source relationships to present the likely root cause to the building operator as described in ASHRAE Guideline 36. Load/Source relationships shall be configurable by the user through a web interface.
11. Reports and Logs.
- a. The building operator web interface shall provide a reporting package that allows the operator to select reports.
 - b. The building operator web interface shall provide the ability to schedule reports to run at specified intervals of time.
 - c. The following standard reports shall be available without requiring a user to manually configure the report:
 - 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 in effect.
 - 3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - 4) Points report: Provide a report that lists the current value of all points
 - d. The controls vendor shall provide a hardening report that summarizes the port configuration details to ensure sites have not been exposed to the Internet in alignment with Cyber Security best practices.

B. Provide Mobile App Interface

- 1. Provide mobile (smart phone or tablet) interfaces to the building automation system, compatible with iOS and Android™ operating systems.
- 2. Controls manufacturer shall provide a phone/tablet interface with the ability to view/override status and setpoints, view/change schedules, view/acknowledge/comment on alarms, and view graphics for all spaces and equipment.

3. This phone/tablet interface shall resize itself appropriately for the size of the interface (i.e. no "pinching and zooming" required).
4. This phone/tablet interface shall function remotely from the facility while following IT security best practices (e.g. no ports exposed to the internet).
5. The operator interface shall support system access on a mobile device via a mobile app to:
 - a. Alarm log
 - b. System Status
 - c. Equipment status
 - d. Space Status
 - e. Standard Equipment graphics
 - f. Override set points
 - g. Override occupancy
 - h. Acknowledge Alarms
 - i. Add Comment(s) to Alarms

BUILDING CONTROLLER SOFTWARE

- A. Manufacturer shall provide standard applications to deliver HVAC system control. Standard applications include Time of Day Scheduling with Optimal Start/Stop, VAV Air Systems Control, Chiller Plant Control, Historical Trend Logs and Trim and Respond. Manufacturer shall provide system optimization strategies for functions such as fan pressure optimization and ventilation optimization.
- B. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the building operator interface.
 1. VAV Air Systems Applications
 - a. The BAS shall provide air system applications that coordinate air handlers (AHU)/rooftop units (RTU) and Variable Air Volume Terminal equipment.
 - b. The air system applications shall perform the following functions:
 - 1) Startup and shutdown the air handler safely. Ensure the VAV boxes are open sufficiently when the air handler is running, to prevent damage to the ductwork and VAV boxes due to high air pressure.

- 2) Fan Pressure Optimization (ASHRAE 90.1, Guideline 36) - Minimize energy usage by controlling system static pressure to the lowest level while maintaining zone airflow requirements. Trim and respond reset logic shall reset setpoint within the range of min and max values based on zone requests.
 - 3) During commissioning, and with the engineer/owner, the controls contractor shall confirm the performance of Fan Pressure Optimization by conducting a field functional test that demonstrates critical zone reset.
 - 4) Ventilation Optimization (ASHRAE 62) – properly ventilate all spaces while minimizing operating energy costs, using measured outdoor air flow. Dynamically calculate the system outdoor air requirement based on “real time” conditions in the spaces (i.e., number of occupants, CO2 levels, etc.) minimizing the amount of unconditioned outdoor air that must be brought into the building.
 - 5) Demand Controlled Ventilation – the active ventilation setpoint shall modulate between the occupied ventilation and occupied standby ventilation setpoint; Resetting the setpoint based on CO2 levels in the space.
 - 6) Discharge Air Temperature Reset (ASHRAE 90.1, Guideline 36) - Minimize energy usage by controlling discharge air temperature in response to building loads and outdoor air temperature. Trim and respond reset logic shall reset setpoint within the range of min and max values based on zone requests.
- c. The Air Systems application shall provide a user interface that includes status of current system operation with real time data of key operating parameters. Key operating parameters for Guideline 36 include:
- 1) Duct Static Pressure
 - 2) Duct Static Optimization Setpoint
 - 3) Outdoor Airflow
 - 4) Ventilation Optimization Setpoint
 - 5) Duct Static Optimization Maximum VAV Damper/Source VAV Box
 - 6) Ventilation Optimization Maximum VAV Vent Ratio/Source VAV box
 - 7) Discharge Air Temperature
 - 8) Discharge Air Temperature Optimization Setpoint
 - 9) Duct Static Optimization System Requests
 - 10) Discharge Air Temperature Optimization System Requests
- d. The air system application status screens shall explain what optimization calculations are occurring, critical parameters, and source equipment members. The

optimization status, inputs, and results shall be displayed for VAV Ventilation Optimization (calculating proper outside air intake), VAV Discharge Air Temperature Optimization (calculating proper discharge air temperature) and VAV Duct Static Pressure Optimization (calculating proper fan static pressure).

- e. The air systems applications shall provide a user interface that enables configuration changes made by swipe and type fields, selection list, and check box entry for feature definition:
 - 1) VAV Auxiliary Night Heat
 - 2) VAV Source Temperature Distribution
 - 3) Changeover System control
 - 4) Start/Stop Delay operation
 - 5) Enable/Disable Optimization Strategies (Duct Static Optimization, Discharge Air Temperature Optimization and Ventilation Optimization)
- f. The operation of VAV Terminal equipment members of the VAV Air System shall be selected by check box to optionally participate in the following functions when for Guideline 36 applications:
 - 1) System calculations (min, max, average)
 - 2) Duct Pressure Optimization
 - 3) Ventilation Optimization
 - 4) Drive to Maximum Override
 - 5) Common Source Temperature
 - 6) Common Space
 - 7) Discharge Air Temperature Optimization
 - 8) Hot Water Temperature Optimization
 - 9) Chilled Water Temperature Optimization
- g. The air system application vendor shall provide a published applications guide that details the air system application operation, configuration, setup, and troubleshooting. The applications guide documentation shall be maintained under version control, and updated by the manufacture to reflect most recent feature updates as made available. Contents of the guide shall include:
 - 1) Description of System Operation
 - 2) Required Components

- 3) Sequences of Operation
 - 4) Installation
 - 5) Controller Setup
 - 6) Required Programming
 - 7) Commissioning
 - 8) Optimization Strategies
 - 9) Special Applications
 - 10) Troubleshooting
- h. The air system application shall present in plain user language the current operation with source zone information and reset events.
2. Trend Logs
- a. The system shall harvest trend logs for defined key measurements for each controlled HVAC device and HVAC application. Trend logs shall be captured for a minimum of 5 key operating points for each piece of HVAC equipment and HVAC application and stored for no less than 1 year at 15-minute intervals. Data Logs shall be capable of being configured on an interval or change of value basis.
- 1) Fan Coil
 - (a) Discharge Air Temperature
 - (b) Space Temperature Active
 - (c) Space Temperature Setpoint Active
 - (d) Air Flow Setpoint Active
 - (e) Discharge Air Flow
 - 2) Water Source Heat Pump
 - (a) Discharge Air Temperature
 - (b) Space Temperature Active
 - (c) Space Temperature Setpoint Active
 - (d) Air Flow Setpoint Active
 - (e) Discharge Air Flow
 - 3) Air Handling Unit/Rooftop (VAV)

- (a) Discharge Air Temperature
 - (b) Discharge Air Temperature Setpoint Active
 - (c) Space Temperature Active
 - (d) Cooling Capacity Status
 - (e) Discharge Air Flow
- 4) Air Handling Unit/Rooftop (CV)
 - (a) Discharge Air Temperature
 - (b) Space Temperature Active
 - (c) Space Temperature Setpoint Active
 - (d) Cooling Capacity Status
 - (e) Heating Capacity Primary Status
 - (f) Outdoor Air Damper Position
- 5) VAV Box
 - (a) Discharge Air Temperature
 - (b) Space Temperature Active
 - (c) Space Temperature Setpoint Active
 - (d) Air Flow Setpoint Active
 - (e) Discharge Air Flow
- 3. Trim and Respond
 - a. The BAS shall provide a setpoint reset application program based on 'trim and respond' functionality as outlined in ASHRAE Guideline 36.

BUILDING / SYSTEM CONTROLLERS

- A. There shall be one or more independent, standalone microprocessor based System Controllers to manage the global strategies described in CONTROLLER SOFTWARE section.
 - 1. The controller shall provide a USB communications port for connection to a PC.
 - 2. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

3. All System Controllers shall have a real time clock and shall be able to accept a BACnet time synchronization command for automatic time synchronization.
 4. Data shall be shared between networked System Controllers.
 5. Serviceability – The System Controller shall have a display on the main board that indicates the current operating mode of the controller.
- B. Controls manufacturer shall provide secure remote access to the Building Automation System (BAS). Secure remote access shall not require IP ports to be "exposed" (i.e. port-forwarded or external public IP addresses) to the Internet. Controls manufacturer shall update secure remote access software as necessary to follow cyber security best practices and respond to cyber security events.

ADVANCED APPLICATION CONTROLLERS:

- A. Advance Application Controllers shall be used to control all equipment or applications of medium and high complexity, including but not limited to Air Handlers, Boiler Plants and Chiller Plants.
- B. The Advanced Application Controller shall be capable of operating as a stand-alone controller or as a member of a Building Automation System (BAS).
- C. When the Advanced Application Controller is operating as a member of a Building Automation System (BAS), the application controller shall operate as follows:
1. Application Controller will receive operation mode commands from the BAS network controller. The BAS commands shall include but not be limited to the follow: Occupied Heat/Cool, Unoccupied Heat/Cool, Morning Warm-up, / Pre-cool, Occupied Bypass).
 2. Application Controller will provide equipment status parameters to the BAS through BACnet communication.
 3. Application Controller will operate as a stand-alone controller in the event of communication failure with the BAS.
 4. In case of communications failure, stand-alone operation shall use default values or last known values for remote sensors read over the network such as outdoor air temperature.
- D. For Stand-Alone Operation of Advanced Application Controllers:
1. Shall operate a schedule in a standalone application using a Real Time Clock with a 7 day power backup.
 - a. The Controller shall have a built in schedule (assessable with or without a display)
 - b. Support will be for at least 3 schedules with up to 10 events for each day of the week.
 - c. Each of the 3 schedules can be Analog, Binary or Multi-State

- d. The controller shall support a minimum of 25 exceptions each with up to 10 events.
- E. For ease of troubleshooting, the Controller shall support data trend logging.
 - 1. With a minimum of 20,000 trending points total on a controller
 - 2. Trends shall be capable of being collected at a minimum sample rate of once every second
 - 3. Shall be capable of trending all BACnet points used by controller
 - 4. Trends shall be capable of being scheduled or triggered.
- F. To meet the sequence of operation for each application, the Controller shall use library programs provided by the controller manufacturer that are either factory loaded or downloaded with service tool to the controller.
- G. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.
 - 1. Operating conditions:
 - a. Temperature: -40°F to 158°F (-40°C to 70°C)
 - b. Relative Humidity: 5% to 100% RH (non-condensing)
 - 2. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum.
 - 3. 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].
- H. Input/Output: The Controller shall have on board or through expansion module all I/O capable of performing all functionality needed for the application. Controls provided by the equipment manufacture must supply the required I/O for the equipment. In addition other controls must meet the following requirements:
 - 1. Shall support flexibility in valve type, the controllers shall be capable of supporting the following valve control types: 0-10VDC, 0-5VDC, 4-20mA, 24VAC - 2 position.
 - 2. Shall support flexibility in sensor type, the Controller shall be capable of reading sensor input ranges of 0 to10V, 0 to 20mA, 50ms or longer pulses, 200 to 20Kohm and RTD input.
 - 3. Shall support flexibility in sensor type, all Analog Outputs shall have the additional capability of being programmed to operate as Universal Inputs or Pulse Width Modulation Outputs.
 - 4. Shall support flexibility in sensor type, the Controller and/or expansion modules shall support dry and wetted (24VAC) binary inputs.
 - 5. The controller shall support pulse accumulator for connecting devices like energy meters.

6. In order to support a wide range of devices, the Controller's binary output shall be able to drive at least 10VA each.
 7. For future needs, any unused I/O that is not needed for the functionality of the equipment shall be available to be used by custom programs on the Controller and by any other controller on the network.
 8. The Controller shall provide 24VAC and 24VDC power terminals sensors and other devices required.
 9. The Controller shall provide a dedicated static pressure input.
- I. Input/Output Expandability – The Controller shall provide the following functionality in order to meet current and future application needs:
1. For the application flexibility, the Controller shall be capable of expanding to a total of at least 100 hardware I/O terminations.
 2. Expansion I/O can be mounted up to 650 ft. (200m) from control.
 3. For optimized system operation, expansion I/O must communicate via an internal controller communication bus (point expansion via the BACnet MS/TP network is not allowed).
- J. Serviceability – The Controller shall provide the following in order to improve serviceability of the Controller.
1. 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.
 2. Binary and analog inputs and outputs shall use removable connectors or be connected to terminal strip external to the control box.
 3. Software service tool connection through the following methods: direct cable connection to the Controller, connection through another controller on BACnet link
 4. For safety purposes, the controller shall be capable of being powered by a portable computer's USB port for the purposes of configuration, programming and testing programs so that this work can be accomplished with the power off to the associated equipment.
 5. The Controller software tool service port shall utilize standard off-the-shelf USB printer cable.
 6. Capabilities to temporarily override the BACnet point values with built-in time expiration in the Controller.
 7. To aid in service replacement, the Controller shall easily attached to standard DIN rail mounting.

8. For future expansion, the Controller shall be capable of adding sequence of operation programming utilizing service tools software with a graphical programming interface (editing or programming in line code is not permissible).
 9. To aid in service replacement, the Controller shall allow for setting its BACnet address via controller mounted rotary switches that correspond to the numerical value of the address. (DIP switch methodologies are not allowed). Setting of the address shall be accomplished without the need of a service tool or power applied to the controller.
 10. Controller data shall be maintained through a power failure.
- K. 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.
- L. Controller must meet the following Agency Compliance:
1. UL916 PAZX, Open Energy Management Equipment
 2. UL94-5V, Flammability
 3. FCC Part 15, Subpart B, Class B Limit
 4. BACnet Testing Laboratory (BTL) listed as BACnet Advanced Application Controller (B-AAC)

APPLICATION SPECIFIC CONTROLLERS:

- A. General Description
1. Application Specific Controllers (ASC) shall be microprocessor-based DDC controllers which, through hardware or firmware design, control specified equipment. They are not user programmable, but are customized for operation within the confines of the equipment they are designed to serve.
 2. Zone Controllers are controllers that operate equipment that control the space temperature of single zone. Examples are controllers for VAV, Fan coil, Blower Coils, Unit Ventilators, Heat Pumps, and Water Source Heat Pumps.
- B. The Application Specific Controller shall be capable of operating as a stand-alone controller or as a member of a Building Automation System (BAS).
- C. When the Application Specific Controller is operating as a member of a Building Automation System (BAS), the application controller shall operate as follows:
1. Application Controller will receive operation mode commands from the BAS network controller. The BAS commands shall include but not be limited to the follow: Occupied Heat/Cool, Unoccupied Heat/Cool, Morning Warm-up, / Pre-cool, Occupied Bypass).
 2. Application Controller will provide equipment status parameters to the BAS through BACnet communication.

3. Application Controller will operate as a stand-alone controller in the event of communication failure with the BAS.
 4. In case of communications failure stand-alone operation shall use default values or last known values for remote sensors read over the network such as outdoor air temperature.
- D. Stand-Alone Operation: Each piece of equipment specified in section "A" shall be controlled by a single controller and provide stand-alone control in the event that a BAS is not present.
- E. Software
1. To meet the sequence of operation for each zone control, the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or downloaded with service tool to the controller.
 2. For controlling ancillary devices and for flexibility to change the sequence of operation in the future, the controller shall be capable running custom programs written in a graphical programming language.
- F. Environment: Controller hardware shall be suitable for the anticipated ambient conditions.
1. Storage: -55° to 203° F (-48° to 95° C) and 5 to 95% Rh, non-condensing.
 2. Operating: -40° to 158° F (-40 to 70° C) and 5 to 95% Rh, non-condensing.
 3. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum.
 4. 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° to 158° F [-40° to 70° C].
- G. Input/Output:
1. 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 Open or Normally Closed).
 2. 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.
 3. For flexibility in selection and replacement of binary devices, the controller shall support dry and wetted (24VAC) binary inputs.
 4. For flexibility in selection and replacement devices, the controller's shall have binary output which are able to drive at least 12VA each.
 5. 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).

6. For future needs, any I/O that is unused by functionality of equipment control shall be available to be used by custom program on the controller and by another controller on the network.
 7. For future expansion and flexibility, the controller shall have either on board or through expansion, 20 hardware input/output points. Expansion points must communicate with the controller via an internal communications bus. Expansion points must be capable of being mounted up to 650ft. (200 m) from the controller. Expansion points that require the BACnet network for communication with the controller are not allowed.
- H. Serviceability – The controller shall provide the following in order to improve serviceability of the controller.
1. Diagnostic LEDs shall indicate correct operation or failures/faults for all of the following: power, sensors, BACnet communications, and I/O communications bus.
 2. All binary output shall have LED's indicating the output state.
 3. All wiring connectors shall removable without the use of a tool.
 4. Software service tool connection through all of the following methods: direct cable connection to the controller, connection through another controller on BACnet link
 5. For safety purposes, the controller shall be capable of being powered by a portable computer for the purposes of configuration, programming, and testing programs so that this work can be accomplished with the power off to the equipment.
 6. Capabilities to temporarily override of BACnet point values with built-in time expiration in the controller.
 7. BACnet MAC Address shall be set using decimal (0-9) based rotary switches.
 - a. Configuration change shall not be made in a programming environment, but rather by a configuration page utilizing dropdown list, check boxes, and numeric boxes.
 8. For ease of troubleshooting, the Controller shall support BACnet data trend logging.
 - a. With a minimum of 20,000 trending points total on controller
 - b. Trends shall be capable of being collected at a minimum sample rate of once every second.
 - c. Shall be capable of trending all BACnet points used by controller
 - d. Trends shall be capable of being scheduled or triggered
- I. 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.
- J. Application controller shall meet the following Agency Compliance:

1. UL916 PAZX, Open Energy Management Equipment
2. UL94-5V, Flammability
3. FCC Part 15, Subpart B, Class B Limit
4. BACnet Testing Laboratory (BTL) listed as BACnet Application Specific Controller (B-ASC)

APPLICATION CONTROLLER FOR PACKAGED ROOFTOP UNITS

- A. The Rooftop Unit (RTU) Application Controller shall be a microprocessor-based DDC controller which, through hardware or firmware design, controls specified equipment. The controller is not user programmable, but is customized for operation within the confines of the equipment it is designed to serve.
- B. The Application Controller shall be capable of operating as a stand-alone controller or as a member of a Building Automation System (BAS).
- C. When the Application Controller is operating as a member of a Building Automation System (BAS), the application controller shall operate as follows:
 1. Application Controller will receive operation mode commands from the BAS network controller. The BAS commands shall include but not be limited to the follow: Occupied Heat/Cool, Unoccupied Heat/Cool, Morning Warm-up, / Pre-cool, Occupied Bypass).
 2. Application Controller will provide equipment status parameters to the BAS through BACnet communication.
 3. Application Controller will operate as a stand-alone controller in the event of communication failure with the BAS.
 4. In case of communications failure stand-alone operation shall use default values or last known values for remote sensors read over the network such as outdoor air temperature.
- D. Software
 1. To meet the sequence of operation for each zone control, the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or customized with use of service tool native to the controller.
- E. Environment: Controller hardware shall be suitable for the anticipated ambient conditions.
 1. Storage: -55° to 203° F (-48° to 95° C) and 5 to 95% Rh, non-condensing.
 2. Operating: -40° to 158° F (-40 to 70° C) and 5 to 95% Rh, non-condensing.
 3. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum.
 4. 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° to 158° F [-40° to 70° C].

- F. Controller Input/Output: The controller shall have on board capable of performing all functionality needed for the application. Controls provided by the equipment manufacture must supply the required I/O for the equipment.
 - 1. For flexibility in selection and replacement of valves, the controllers shall be capable of supporting all of the following output types; 0-10VDC, 0-5VDC, 4-20mA, Binary.
 - 2. For flexibility in selection and replacement of sensors, the controllers shall be capable of reading sensor input ranges of 0 to10V, 0 to 20mA, Pulse counts, and 200 to 20Kohm.
- G. Serviceability – The controller shall provide the following in order to improve serviceability of the controller.
 - 1. Diagnostic LEDs shall indicate correct operation or failures/faults for all of the following: power, sensors, BACnet communications, and I/O communications bus.
 - 2. All binary output shall have LED's indicating the output state.
 - 3. All wiring connectors shall removable without the use of a tool.
 - 4. Software service tool connection through the following methods: direct cable connection to the controller, connection through another controller on BACnet link.
- H. 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.
- I. Controller shall meet the following Agency Compliance:
 - 1. UL916 PAZX, Open Energy Management Equipment
 - 2. UL94-5V, Flammability
 - 3. FCC Part 15, Subpart B, Class B Limit
 - 4. BACnet Testing Laboratory (BTL) listed

VARAIBLE AIR VOLUME TERMINAL UNIT CONTROLLERS

- A. General Description
 - 1. Variable Air Volume (VAV) controllers shall be microprocessor-based DDC controllers which, through hardware or firmware design, control specified equipment. They are typically not user programmable, but are configurable for operation of VAV terminal units.
 - 2. Variable Air Volume (VAV) controllers are controllers that operate equipment that control the space temperature of single zone.
- B. The VAV controller shall be capable of operating as a stand-alone controller or as a member of a Building Automation System (BAS).

- C. When the VAV controller is operating as a member of a Building Automation System (BAS), the application controller shall operate as follows:
1. The VAV controller will receive operation mode commands from the BAS network controller. The BAS commands shall include but not be limited to the following: Occupied Heat/Cool, Unoccupied Heat/Cool, Morning Warm-up, / Pre-cool, Occupied Bypass).
 2. The VAV controller will provide equipment status parameters to the BAS through BACnet communication.
 3. The VAV controller will operate as a stand-alone controller in the event of communication failure with the BAS.
 4. In case of communications failure stand-alone operation shall use default values or last known values for remote sensors read over the network such as outdoor air temperature.
- D. Stand-Alone Operation: Each VAV Terminal Unit shall be controlled by a single controller and provide stand-alone control in the event that a BAS is not present.
- E. The VAV controller shall communicate to the building automation system via one of the following protocols: BACnet™ MS/TP or BACnet™ Zigbee defined in ANSI®/ASHRAE® Standard 135-2020
1. BACnet™ MS/TP
 - a. To allow maximum communications speed and co-existence with other controllers, the controller shall support at a minimum the following BACnet MS/TP manager baud rates: 9600, 19200, 38400, 76800.
 2. BACnet™ Zigbee
 - a. VAV controller wireless communication interface shall self-form and self-heal to maintain operation in the event of network communication failure.
 - b. IEEE 802.15.4 radios to minimize risk of interference, reliability, and range.
 - c. 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.
 - d. To protect against harmful interference, certifications shall include Energy Management Equipment FCC CFR47, Section 15.247 & subpart E, Digital Modulation Transmission with no SAR (FCC ID: TPF-251701)
- F. Each VAV terminal unit shall use a space zone sensor(s) to measure the space condition it is serving.
1. The VAV controller shall use a wired or wireless communication interface to connect to its space zone sensor.

2. Each zone sensor communication interface shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications. Sensing options shall include temperature, relative humidity, CO₂, and occupancy.
3. Wireless zone sensors
 - a. To check for proper operation, wireless zone temperature sensors shall include a signal strength and battery condition indicators on the zone sensor.
 - b. The wireless zone sensor battery life shall provide at least 15 years life under normal operating conditions and must be readily available Lithium size AA, 1.5V.
 - c. The wireless zone sensor and receiver addresses shall be held in non-volatile memory to ensure operation through system voltage disturbances and to minimize the risk of incorrect association.
 - d. To ensure proper system performance, the wireless zone sensor shall automatically determine when the space temperature is rapidly changing. When the space temperature is readily changing, the space temperature shall be transmitted at least once each 30 seconds. The maximum time between transmissions shall be 15 minutes.
 - e. Zone temperature sensing accuracy shall be +/- 0.5F (+/- 0.28C).

G. Software

1. To meet the sequence of operation for each zone control, the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or downloaded with service tool to the controller.
2. For controlling ancillary devices and for flexibility to change the sequence of operation in the future, the controller shall be capable running custom programs written in a graphical programming language.

H. Environment: Controller hardware shall be suitable for the anticipated ambient conditions.

1. Storage: -55° to 203° F (-48° to 95° C) and 5 to 95% Rh, non-condensing.
2. Operating: -40° to 158° F (-40 to 70° C) and 5 to 95% Rh, non-condensing.
3. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum.
4. 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° to 158° F [-40° to 70° C].

I. Input/Output:

1. 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 Open or Normally Closed).

2. 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, and 200 to 20Kohm.
 3. For flexibility in selection and replacement of binary devices, the controller shall support dry and wetted (24VAC) binary inputs.
 4. For flexibility in selection and replacement devices, the controller shall have binary output which are able to drive at least 12VA each.
 5. 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).
- J. Serviceability – The controller shall provide the following in order to improve serviceability of the controller.
1. Diagnostic LEDs shall indicate correct operation or failures/faults for all of the following: power, sensors, BACnet communications, and I/O communications bus.
 2. All binary output shall have LED's indicating the output state.
 3. All wiring connectors shall removable without the use of a tool.
 4. Software service tool connection through all of the following methods: direct cable connection to the controller, connection through another controller on BACnet link and through the controller's zone sensor.
 5. For safety purposes, the controller shall be capable of being powered by a portable computer for the purposes of configuration, programming, and testing programs so that this work can be accomplished with the power off to the equipment.
 6. Capabilities to temporarily override of BACnet point values with built-in time expiration in the controller.
 7. BACnet MAC Address shall be set using decimal (0-9) based rotary switches.
 - a. Configuration change shall not be made in a programming environment, but rather by a configuration page utilizing dropdown list, check boxes, and numeric boxes.
 8. For ease of troubleshooting, the Controller shall support BACnet data trend logging.
 - a. Trends shall be capable of being collected at a minimum sample rate of once every second.
 - b. Shall be capable of trending all BACnet points used by controller
 - c. Trends shall be capable of being scheduled or triggered
- K. 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.

- L. Controller shall meet the following Agency Compliance:
1. UL916 PAZX, Open Energy Management Equipment
 2. UL94-5V, Flammability
 3. FCC Part 15, Subpart B, Class B Limit
 4. AS/NZS CISPR 32:2016
 5. VCCI-CSPR 32:2016
 6. CAN ICES-003(B)/NMB-003(B)
 7. To ensure integration to the building automation system the controller must be BTL (BACnet Testing Lab) listed. The following BACnet profiles are in order of most functionality (B-BC) to least functionality (B-ASC).
 - a. BACnet Building Controller (B-BC)
 - b. BACnet Advance Applications Controller (B-AAC)
 - c. BACnet Application Specific Controller (B-ASC)

INPUT/OUTPUT INTERFACE:

- A. Hardwired inputs and outputs may tie into the system through building, custom application, or ASCs.
- B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.
- C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
- D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
- E. Analog inputs shall allow the monitoring of low voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- F. Binary outputs shall provide for on/off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have status lights. Outputs shall be selectable for either normally open or normally closed operation.

- G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.
- H. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
- I. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

POWER SUPPLIES:

- A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish overcurrent protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
 - 1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in overvoltage and overcurrent protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA approved.

AUXILIARY CONTROL DEVICES:

- A. Motorized dampers, unless otherwise specified elsewhere, shall be as follows:
 - 1. Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.
 - 2. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.
 - 3. Damper shaft bearings shall be as recommended by manufacturer for application.
 - 4. All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.

5. All leakage testing and pressure ratings will be based on AMCA Publication 500.
 6. Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.
- B. Control dampers shall be parallel or opposed blade types as scheduled on drawings.
- C. Electric damper/valve actuators
1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
 2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
 3. All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
 4. Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
 5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
 6. Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
 7. Actuators shall be Underwriters Laboratories Standard 873 listed.
 8. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
- D. Control Valves
1. Control valves shall be two-way or three-way type for two-position or modulating service as scheduled or shown.
 2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - a. Water Valves:
 - 1) Two-way: 150% of total system (pump) head.
 - 2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
 - b. Steam Valves: 150% of operating (inlet) pressure.

E. Water Valves

1. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
2. Sizing Criteria:
 - a. Two-position service: Line size.
 - b. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 34.5 kPa (5 psi), whichever is greater.
 - c. Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 34.5 kPa (5 psi) maximum.
 - d. Valves DN 15 (1/2 in.) through DN 50 (2 in.) shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
 - e. Valves DN 65 (2 1/2 in.) and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
3. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
 - a. Water zone valves—normally open preferred
 - b. Heating coils in air handlers - normally open
 - c. Chilled-water control valves - normally closed
 - d. Other applications—as scheduled or as required by sequences of operation
4. Zone valves shall be sized to meet the control application and they shall maintain their last position in the event of a power failure.

F. Steam Valves

1. Body and trim materials shall be in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service.
2. Sizing Criteria:
 - a. Two-position service: pressure drop 10% to 20% of inlet psig
 - b. Modulating service: 100 kPa (15 psig) or less; pressure drop 80% of inlet psig
 - c. Modulating service: 101 to 350 kPa (16 to 50 psig); pressure drop 50% of inlet psig
 - d. Modulating service: over 350 kPa (50 psig); pressure drop as scheduled on plans

G. Binary Temperature Devices

1. Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
2. Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
3. Low-limit thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.

H. Wired Temperature Sensors

1. Temperature sensors shall be RTD or thermistor.
2. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross section.
3. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
4. Space sensors shall be equipped with setpoint adjustment, override switch, display, and/or communication port as shown on plans.
5. Provide matched temperature sensors for differential temperature measurement.

I. Wired Humidity Sensors

1. Duct and room sensors shall have a sensing range of 20% to 80%.
2. Duct sensors shall be provided with a sampling chamber.

J. Static Pressure Sensors

1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 ma output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.

4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 ma output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.

K. Low Limit Thermostats

1. Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.
2. Low limit shall be manual reset only.

WIRING AND RACEWAYS:

- A. General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of this specification.
- B. All insulated wire to be copper conductors, UL labeled for 90°C (194°F) minimum service.
- C. Fiber Optic Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. The sheath shall be UL Listed OFNP in accordance with NEC Article 770. The optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.

PART 3 EXECUTION

27.1 SECTION INCLUDES

- A. EXAMINATION:
- B. PROTECTION:
- C. COORDINATION:
- D. GENERAL WORKMANSHIP:
- E. FIELD QUALITY CONTROL:
- F. COMMUNICATION WIRING:
- G. FIBER OPTIC CABLE:
- H. INSTALLATION OF SENSORS:
- I. FLOW SWITCH INSTALLATION:
- J. WARNING LABELS:
- K. IDENTIFICATION OF HARDWARE AND WIRING:
- L. CONTROLLERS:

M. PROGRAMMING:

N. CONTROL SYSTEM CHECKOUT AND TESTING:

O. CLEANING:

P. TRAINING:

EXAMINATION:

- A. The Contract Documents shall be thoroughly examined for coordination of control devices, their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- B. The BAS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

PROTECTION:

- A. The BAS installation contractor shall protect all work and material from damage by their work or personnel, and shall be liable for all damage thus caused.
- B. The BAS manufacturer shall be responsible for their work and equipment until final inspection, testing, and acceptance. The BAS installing contractor shall protect their work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

COORDINATION:

- A. Site
 - 1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - 2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.
- B. Submittals. Refer to the "Submittals," section of this specification for requirements.
- C. Test and Balance
 - 1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

2. The contractor shall provide training in the use of these tools. This training will be planned for a duration of 4 hours.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process shall be returned to the contractor at the completion of the testing and balancing.

D. Life Safety

1. Duct smoke detectors required for air handler shutdown shall be supplied under Section 26100 of this specification. The contractor shall interlock smoke detectors to air handlers for shutdown as described in the Sequences of Operation for this project.
2. Smoke dampers and actuators required for duct smoke isolation are provided under Section 26100. The contractor shall interlock these dampers to the air handlers as described in the Sequences of Operation for this project as applicable.
3. Fire/smoke dampers and actuators required for fire rated walls are provided under another Section 26100. Control of these dampers shall be by 26100

E. Coordination with Controls Specified in Other Sections or Divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified in the "Communication" section of this specification.
2. Each supplier of a controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
3. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.

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.

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.

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 lightning 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.

FIBER OPTIC CABLE:

- A. All cabling shall be installed in a neat and workmanlike manner. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.
- B. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post installation residual cable tension shall be within cable manufacturer's specifications.

- C. Fiber optic cabinets, hardware, and cable entering the cabinet shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

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. 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 outdoor air temperature sensors on north wall complete with sun shield at manufacturer's recommended location and coordinated with Engineer.

FLOW SWITCH INSTALLATION:

- A. Coordinate installation of flow switch with Mechanical Contractor who will be responsible for installing a thread o let in steel piping applications. Copper pipe applications will require the use CxCxF Tee, and no pipe extensions or substitutions will be allowed.
- B. Mount a minimum of 5 pipe diameters upstream and 5 pipe diameters downstream, or two feet, whichever is greater, from pipe fittings and other inline potential obstructions.

- C. Install in accordance with manufacturers' instructions, which will require proper flow direction, horizontal alignment with flow switch mounting on the top of pipe.

WARNING LABELS:

- A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the BAS system.
- B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

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.

CONTROLLERS:

- A. Provide a separate DDC Controller for individual HVAC mechanical equipment. BAS manufacturer shall furnish and coordinate DDC controllers and control devices and ensure that installation and wiring adhere to BAS manufacturer's design recommendations. For those mechanical equipment units that do not have factory installed controls specified, the BAS manufacturer shall field mount controls and coordinate all installation and termination information to ensure the specified sequence of operations are met.
- B. Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type (analog or digital) found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used in each controller.
 - 1. Future use of spare I/O point capacity shall require providing the field instrument and control device, field wiring, engineering, programming, and commissioning. No additional Controller boards or point modules shall be required to implement use of these spare points.

PROGRAMMING:

- A. Provide sufficient internal memory for all controllers to ensure specified sequence of operations, alarming, trending, and reporting requirements are achieved. BAS manufacturer shall provide a minimum of 25% spare memory capacity for future use.
- B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.
- C. Software Programming
 - 1. Provide programming for individual mechanical systems to achieve all aspects of the sequence of operation specified. It is the BAS manufacturer's responsibility to ensure all mechanical equipment functions and operates as specified in sequence of operations. Provide sufficient programming comments in controller application software to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.
- D. BAS Operator's Interface
 - 1. When Operator Workstation is specified, provide color graphics for each piece of mechanical equipment depicting sufficient I/O to monitor and troubleshoot operation. Operator color graphics shall include Chiller Plant, Cooling Tower System, Boiler Plant, Air Handling Units, Rooftop Units, VAV Terminal Boxes, Fan Coil Units, Unit Ventilators, Heat Exchangers, Exhaust Fans, etc. These standard graphics shall depict all points dynamically as specified in the points list and/or indicated in sequence of operation.
 - 2. The BAS manufacturer shall provide all the labor necessary to install, initialize, start up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third party software installation and integration required for successful operation of the operator interface.
 - 3. As part of this execution phase, the BAS manufacturer shall perform a complete test of the operator interface.

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.

CLEANING:

- A. 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.

TRAINING:

- A. Provide minimum of (4) hours of operator training 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

END OF SECTION

This page intentionally left blank

SECTION 23 0910 - EXISTING BAS INTEGRATION

BUILDING AUTOMATION SYSTEM - GENERAL DESCRIPTION

PROVIDE AN EXTENSION OF THE EXISTING BUILDING AUTOMATION SYSTEM (BAS) TO INTEGRATE AND CONTROL ALL MECHANICAL EQUIPMENT ASSOCIATED WITH THIS PROJECT. ALL NEW BUILDING CONTROLLERS, AND EQUIPMENT/PLANT CONTROLLERS, SHALL BE INTEGRATED INTO THE EXISTING COUNTY-WIDE TRANE CONNECT SYSTEM.

- 2.1 THE EXISTING BUILDING BAS IS TRANE TRACER.**
- 2.2 THE BUILDING AUTOMATION SYSTEM SHALL BE AS INDICATED ON THE DRAWINGS AND DESCRIBED IN THESE SPECIFICATIONS. SYSTEM MUST BE FULLY INTEGRATED AND COORDINATED WITH MECHANICAL EQUIPMENT DDC CONTROLLERS FURNISHED AND INSTALLED IN THE EQUIPMENT MANUFACTURER'S FACTORY AS SPECIFIED IN THOSE SECTIONS. THE INTENT OF THE BAS IS TO INTEGRATE ALL MECHANICAL EQUIPMENT INTO ONE SYSTEM FOR GLOBAL MONITORING, CONTROL, AND ALARMING ASSOCIATED WITH THE BUILDING. IT IS THE BAS MANUFACTURER'S RESPONSIBILITY TO PROVIDE ALL THE DESIGN, ENGINEERING, AND FIELD COORDINATION REQUIRED TO ENSURE ALL EQUIPMENT SEQUENCE OF OPERATIONS ARE MET AS SPECIFIED AND THE DESIGNATED BAS OPERATORS HAVE THE CAPABILITY OF MANAGING THE BUILDING MECHANICAL SYSTEM TO ENSURE OCCUPANT COMFORT WHILE MAINTAINING ENERGY EFFICIENCY.**
- 2.3 THE BAS SHALL MEET OPEN STANDARD PROTOCOL COMMUNICATION STANDARDS (AS DEFINED IN SYSTEM COMMUNICATIONS SECTION) TO ENSURE THE SYSTEM MAINTAINS "INTEROPERABILITY" TO AVOID PROPRIETARY ARRANGEMENTS THAT WILL MAKE IT DIFFICULT FOR THE OWNER TO CONSIDER OTHER BAS MANUFACTURERS IN FUTURE PROJECTS.**
- 2.4 DIRECT DIGITAL CONTROL (DDC) TECHNOLOGY SHALL BE USED TO PROVIDE THE FUNCTIONS NECESSARY FOR CONTROL OF MECHANICAL SYSTEMS AND TERMINAL DEVICES ON THIS PROJECT.**
- 2.5 THE BAS SHALL ACCOMMODATE SIMULTANEOUS MULTIPLE USER OPERATION. ACCESS TO THE CONTROL SYSTEM DATA SHOULD BE LIMITED ONLY BY THE SECURITY PERMISSIONS OF THE OPERATOR ROLE. MULTIPLE USERS SHALL HAVE ACCESS TO ALL VALID SYSTEM DATA. AN OPERATOR SHALL BE ABLE TO LOG ONTO ANY WORKSTATION ON THE CONTROL SYSTEM AND HAVE ACCESS TO ALL APPROPRIATE DATA.**

APPROVED CONTROL SYSTEM MANUFACTURERS

APPROVED BAS MANUFACTURERS:

- 4.1 TRANE TRACER®— NO SUBSTITUTIONS**

SYSTEM COMMUNICATION

SYSTEM COMMUNICATIONS

- 6.1 EACH WORKSTATION, BUILDING CONTROLLER, AND EQUIPMENT CONTROLLER COMMUNICATION INTERFACE SHALL UTILIZE THE BACNET™ PROTOCOL WITH AN ETHERNET (IEEE 802.3), WI-FI (IEEE 802.11), RS485 (EIA-485), OR ZIGBEE® (802.15.4) PHYSICAL INTERFACE**

AND AN APPROPRIATE DATA LINK TECHNOLOGY AS DEFINED IN ANSI®/ASHRAE® STANDARD 135-2012. (E.G. BACNET OVER IP, BACNET OVER IPV6, BACNET SC, BACNET OVER MS/TP, BACNET ZIGBEE).

- 6.2 ALL SYSTEM CONTROLLERS SHALL BE BTL LISTED AS A BACNET BUILDING CONTROLLER (B-BC) AS DEFINED IN ANSI®/ASHRAE® STANDARD 135-2012.**
- 6.3 ALL DOCUMENTED STATUS AND CONTROL POINTS, SCHEDULE, ALARM, AND DATA-LOG SERVICES OR OBJECTS SHALL BE AVAILABLE AS STANDARD OBJECT TYPES AS DEFINED IN ANSI®/ASHRAE® STANDARD 135-2012.**
- 6.4 EACH SYSTEM CONTROLLER SHALL COMMUNICATE WITH A NETWORK OF CUSTOM APPLICATION AND APPLICATION SPECIFIC CONTROLLERS UTILIZING ONE OR MORE OF THE INTERFACES DOCUMENTED WITHIN FIELD BUS COMMUNICATIONS BELOW.**
- 6.5 ALL OPERATOR WORKSTATIONS (B-OWS, B-AWS) AND BUILDING CONTROLLERS (B-BC) SHALL SUPPORT BACNET SECURE CONNECT (BACNET SC), A SECURE AND ENCRYPTED DATALINK LAYER SPECIFICALLY DESIGNED FOR THOSE NETWORKS.**

FIELD BUS COMMUNICATIONS

7.1 BACNET™

- A. All equipment and plant controllers shall be BTL listed as a BACnet Application Specific Controller (B-ASC) or a BACnet Advanced Application Controller (B-AAC) as defined in ANSI®/ASHRAE® Standard 135-2012.
- B. All communication shall conform to ANSI®/ASHRAE® Standard 135-2012.
- C. System Controller shall function as a BACnet router to each unit controller providing a globally unique BACnet Device ID for all BACnet controllers within the system.
- D. BACnet Zigbee®
 - 1. Communication between System Controller and equipment/plant controllers shall utilize BACnet Zigbee as defined in ANSI®/ASHRAE® Standard 135-2012.
 - 2. Each equipment controller wireless communication interface shall self-heal to maintain operation in the event of network communication failure.
 - 3. Each zone sensor wireless communication interface shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications. Sensing options shall include temperature, relative humidity, CO2, and occupancy.
- E. BACnet MS/TP
 - 1. Communication between System Controller and equipment/plant controllers shall utilize BACnet MS/TP as defined in ANSI®/ASHRAE® Standard 135-2012.

OPERATOR INTERFACE

PROVIDE BUILDING OPERATOR WEB INTERFACE

9.1 MANUFACTURER SHALL PROVIDE A USER INTERFACE WITH TIME-OF-DAY SCHEDULES, DATA COLLECTION, DASHBOARDS, REPORTS AND BUILDING SUMMARY, SYSTEM APPLICATIONS, AND SELF-EXPIRING TIMED OVERRIDES. MANUFACTURER SHALL PROVIDE A PUBLISHED USER AND APPLICATIONS GUIDE(S) THAT DETAIL THE SYSTEM APPLICATION OPERATION, CONFIGURATION, SETUP AND TROUBLESHOOTING.

9.2 THE BUILDING OPERATOR WEB INTERFACE SHALL BE ACCESSIBLE VIA A WEB BROWSER WITHOUT REQUIRING ANY “PLUG-INS” (I.E. JAVA RUNTIME ENVIRONMENT (JRE), ADOBE FLASH).

9.3 USER ROLES

- A. The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.
- B. User logon/logoff attempts shall be recorded.
- C. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.

9.4 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. On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.

9.5 EQUIPMENT AND APPLICATION PAGES

- A. The building operator web interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
 - 1. Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:
 - a. Each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These graphics shall show all points dynamically as specified in the points list.
 - b. Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.
 - 2. Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
 - 3. Historical Data (As defined in Trend Logs section of CONTROLLER SOFTWARE) for the equipment or application without requiring a user to navigate to a Data Log page and perform a filter.

B. VAV Air System. An operator shall be able to view and control (where applicable) the following parameters via the building operator web interface:

1. System Mode
2. System Occupancy
3. Ventilation (Outdoor air flow) setpoint
4. Ventilation (Outdoor air flow) status
5. Air Handler Static pressure setpoint
6. Air Handler Static pressure status
7. Air Handler occupancy status
8. Air Handler Supply air cooling and heating set points
9. Air Handler minimum, maximum and nominal static pressure setpoints
10. VAV box minimum and maximum flow
11. VAV box drive open and close overrides
12. VAV box occupancy status
13. VAV box Airflow to space
14. Average space temperature
15. Minimum space temperature
16. Maximum space temperature

9.6 SYSTEM GRAPHICS. BUILDING OPERATOR WEB INTERFACE SHALL BE GRAPHICALLY BASED AND SHALL INCLUDE AT LEAST ONE GRAPHIC PER PIECE OF EQUIPMENT OR OCCUPIED ZONE, GRAPHICS FOR EACH CHILLED WATER AND HOT WATER SYSTEM, AND GRAPHICS THAT SUMMARIZE CONDITIONS ON EACH FLOOR OF EACH BUILDING INCLUDED IN THIS CONTRACT. INDICATE THERMAL COMFORT ON FLOOR PLAN SUMMARY GRAPHICS USING COLORS TO REPRESENT ZONE TEMPERATURE RELATIVE TO ZONE SET POINT.

- A. Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
- B. Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
- C. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

9.7 GRAPHICS LIBRARY. FURNISH A LIBRARY OF STANDARD HVAC EQUIPMENT SUCH AS CHILLERS, AIR HANDLERS, TERMINALS, FAN COILS, UNIT VENTILATORS, ROOFTOP UNITS, AND VAV BOXES, IN 3-DIMENSIONAL GRAPHIC DEPICTIONS. THE LIBRARY SHALL BE FURNISHED IN A FILE FORMAT COMPATIBLE WITH THE GRAPHICS GENERATION PACKAGE PROGRAM.

9.8 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 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. Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
- D. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.

9.9 SCHEDULING. - THE SCHEDULING APPLICATION SHALL PROVIDE GRAPHICAL REPRESENTATION OF THE DAY, WEEK, MONTH AND EXCEPTION EVENTS.

9.10 ALARM/EVENT NOTIFICATION

- A. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any building operator web 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. The operator shall be able to acknowledge and add comments to alarms
 - 3. Alarm/event messages shall use full language, easily recognized descriptors.
- B. Alarm Suppression. Alarms shall be able to be suppressed based on load/source relationships to present the likely root cause to the building operator as described in ASHRAE Guideline 36. Load/Source relationships shall be configurable by the user through a web interface.

9.11 REPORTS AND LOGS.

- A. The building operator web interface shall provide a reporting package that allows the operator to select reports.
- B. The building operator web interface shall provide the ability to schedule reports to run at specified intervals of time.
- C. The following standard reports shall be available without requiring a user to manually configure the report:
 - 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 in effect.
 3. Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 4. Points report: Provide a report that lists the current value of all points
- D. The controls vendor shall provide a hardening report that summarizes the port configuration details to ensure sites have not been exposed to the Internet in alignment with Cyber Security best practices.

PROVIDE MOBILE APP INTERFACE

10.1 PROVIDE MOBILE (SMART PHONE OR TABLET) INTERFACES TO THE BUILDING AUTOMATION SYSTEM, COMPATIBLE WITH IOS AND ANDROID™ OPERATING SYSTEMS.

10.2 CONTROLS MANUFACTURER SHALL PROVIDE A PHONE/TABLET INTERFACE WITH THE ABILITY TO VIEW/OVERRIDE STATUS AND SETPOINTS, VIEW/CHANGE SCHEDULES, VIEW/ACKNOWLEDGE/COMMENT ON ALARMS, AND VIEW GRAPHICS FOR ALL SPACES AND EQUIPMENT.

10.3 THIS PHONE/TABLET INTERFACE SHALL RESIZE ITSELF APPROPRIATELY FOR THE SIZE OF THE INTERFACE (I.E. NO "PINCHING AND ZOOMING" REQUIRED).

10.4 THIS PHONE/TABLET INTERFACE SHALL FUNCTION REMOTELY FROM THE FACILITY WHILE FOLLOWING IT SECURITY BEST PRACTICES (E.G. NO PORTS EXPOSED TO THE INTERNET).

10.5 THE OPERATOR INTERFACE SHALL SUPPORT SYSTEM ACCESS ON A MOBILE DEVICE VIA A MOBILE APP TO:

- A. Alarm log
- B. System Status
- C. Equipment status
- D. Space Status
- E. Standard Equipment graphics
- F. Override set points
- G. Override occupancy
- H. Acknowledge Alarms
- I. Add Comment(s) to Alarms

BUILDING / SYSTEM CONTROLLERS

THERE SHALL BE ONE OR MORE INDEPENDENT, STANDALONE MICROPROCESSOR BASED SYSTEM CONTROLLERS TO MANAGE THE GLOBAL STRATEGIES DESCRIBED IN CONTROLLER SOFTWARE SECTION.

12.1 THE CONTROLLER SHALL PROVIDE A USB COMMUNICATIONS PORT FOR CONNECTION TO A PC.

12.2 THE OPERATING SYSTEM OF THE CONTROLLER SHALL MANAGE THE INPUT AND OUTPUT COMMUNICATIONS SIGNALS TO ALLOW DISTRIBUTED CONTROLLERS TO SHARE REAL AND VIRTUAL POINT INFORMATION AND ALLOW CENTRAL MONITORING AND ALARMS.

12.3 ALL SYSTEM CONTROLLERS SHALL HAVE A REAL TIME CLOCK AND SHALL BE ABLE TO ACCEPT A BACNET TIME SYNCHRONIZATION COMMAND FOR AUTOMATIC TIME SYNCHRONIZATION.

12.4 DATA SHALL BE SHARED BETWEEN NETWORKED SYSTEM CONTROLLERS.

12.5 SERVICEABILITY – THE SYSTEM CONTROLLER SHALL HAVE A DISPLAY ON THE MAIN BOARD THAT INDICATES THE CURRENT OPERATING MODE OF THE CONTROLLER.

CONTROLS MANUFACTURER SHALL PROVIDE SECURE REMOTE ACCESS TO THE BUILDING AUTOMATION SYSTEM (BAS). SECURE REMOTE ACCESS SHALL NOT REQUIRE IP PORTS TO BE "EXPOSED" (I.E. PORT-FORWARDED OR EXTERNAL PUBLIC IP ADDRESSES) TO THE INTERNET. CONTROLS MANUFACTURER SHALL UPDATE SECURE REMOTE ACCESS SOFTWARE AS NECESSARY TO FOLLOW CYBER SECURITY BEST PRACTICES AND RESPOND TO CYBER SECURITY EVENTS.

BUILDING CONTROLLER SOFTWARE

MANUFACTURER SHALL PROVIDE STANDARD APPLICATIONS TO DELIVER HVAC SYSTEM CONTROL. STANDARD APPLICATIONS INCLUDE TIME OF DAY SCHEDULING WITH OPTIMAL START/STOP, VAV AIR SYSTEMS CONTROL, CHILLER PLANT CONTROL, HISTORICAL TREND LOGS AND TRIM AND RESPOND. MANUFACTURER SHALL PROVIDE SYSTEM OPTIMIZATION STRATEGIES FOR FUNCTIONS SUCH AS FAN PRESSURE OPTIMIZATION AND VENTILATION OPTIMIZATION.

FURNISH THE FOLLOWING APPLICATIONS SOFTWARE FOR BUILDING AND ENERGY MANAGEMENT. ALL SOFTWARE APPLICATIONS SHALL RESIDE AND RUN IN THE SYSTEM CONTROLLERS. EDITING OF APPLICATIONS SHALL OCCUR AT THE BUILDING OPERATOR INTERFACE.

16.1 VAV AIR SYSTEMS APPLICATIONS

- A. The BAS shall provide air system applications that coordinate air handlers (AHU)/rooftop units (RTU) and Variable Air Volume Terminal equipment.
- B. The air system applications shall perform the following functions:
 - 1. Startup and shutdown the air handler safely. Ensure the VAV boxes are open sufficiently when the air handler is running, to prevent damage to the ductwork and VAV boxes due to high air pressure.
 - 2. Fan Pressure Optimization (ASHRAE 90.1, Guideline 36) - Minimize energy usage by controlling system static pressure to the lowest level while maintaining zone airflow requirements. Trim and respond reset logic shall reset setpoint within the range of min and max values based on zone requests.

3. During commissioning, and with the engineer/owner, the controls contractor shall confirm the performance of Fan Pressure Optimization by conducting a field functional test that demonstrates critical zone reset.
 4. Ventilation Optimization (ASHRAE 62) – properly ventilate all spaces while minimizing operating energy costs, using measured outdoor air flow. Dynamically calculate the system outdoor air requirement based on “real time” conditions in the spaces (i.e., number of occupants, CO2 levels, etc.) minimizing the amount of unconditioned outdoor air that must be brought into the building.
 5. Demand Controlled Ventilation – the active ventilation setpoint shall modulate between the occupied ventilation and occupied standby ventilation setpoint; Resetting the setpoint based on CO2 levels in the space.
 6. Discharge Air Temperature Reset (ASHRAE 90.1, Guideline 36) - Minimize energy usage by controlling discharge air temperature in response to building loads and outdoor air temperature. Trim and respond reset logic shall reset setpoint within the range of min and max values based on zone requests.
- C. The Air Systems application shall provide a user interface that includes status of current system operation with real time data of key operating parameters. Key operating parameters for Guideline 36 include:
1. Duct Static Pressure
 2. Duct Static Optimization Setpoint
 3. Outdoor Airflow
 4. Ventilation Optimization Setpoint
 5. Duct Static Optimization Maximum VAV Damper/Source VAV Box
 6. Ventilation Optimization Maximum VAV Vent Ratio/Source VAV box
 7. Discharge Air Temperature
 8. Discharge Air Temperature Optimization Setpoint
 9. Duct Static Optimization System Requests
 10. Discharge Air Temperature Optimization System Requests
- D. The air system application status screens shall explain what optimization calculations are occurring, critical parameters, and source equipment members. The optimization status, inputs, and results shall be displayed for VAV Ventilation Optimization (calculating proper outside air intake), VAV Discharge Air Temperature Optimization (calculating proper discharge air temperature) and VAV Duct Static Pressure Optimization (calculating proper fan static pressure).

- E. The air systems applications shall provide a user interface that enables configuration changes made by swipe and type fields, selection list, and check box entry for feature definition:
 - 1. VAV Auxiliary Night Heat
 - 2. VAV Source Temperature Distribution
 - 3. Changeover System control
 - 4. Start/Stop Delay operation
 - 5. Enable/Disable Optimization Strategies (Duct Static Optimization, Discharge Air Temperature Optimization and Ventilation Optimization)
- F. The operation of VAV Terminal equipment members of the VAV Air System shall be selected by check box to optionally participate in the following functions when for Guideline 36 applications:
 - 1. System calculations (min, max, average)
 - 2. Duct Pressure Optimization
 - 3. Ventilation Optimization
 - 4. Drive to Maximum Override
 - 5. Common Source Temperature
 - 6. Common Space
 - 7. Discharge Air Temperature Optimization
 - 8. Hot Water Temperature Optimization
 - 9. Chilled Water Temperature Optimization
- G. The air system application vendor shall provide a published applications guide that details the air system application operation, configuration, setup, and troubleshooting. The applications guide documentation shall be maintained under version control, and updated by the manufacture to reflect most recent feature updates as made available. Contents of the guide shall include:
 - 1. Description of System Operation
 - 2. Required Components
 - 3. Sequences of Operation
 - 4. Installation
 - 5. Controller Setup
 - 6. Required Programming

7. Commissioning
 8. Optimization Strategies
 9. Special Applications
 10. Troubleshooting
- H. The air system application shall present in plain user language the current operation with source zone information and reset events.

16.2 TREND LOGS

- A. The system shall harvest trend logs for defined key measurements for each controlled HVAC device and HVAC application. Trend logs shall be captured for a minimum of 5 key operating points for each piece of HVAC equipment and HVAC application and stored for no less than 1 year at 15-minute intervals. Data Logs shall be capable of being configured on an interval or change of value basis.
1. Fan Coil
 - a. Discharge Air Temperature
 - b. Space Temperature Active
 - c. Space Temperature Setpoint Active
 - d. Air Flow Setpoint Active
 - e. Discharge Air Flow
 2. Water Source Heat Pump
 - a. Discharge Air Temperature
 - b. Space Temperature Active
 - c. Space Temperature Setpoint Active
 - d. Air Flow Setpoint Active
 - e. Discharge Air Flow
 3. Air Handling Unit/Rooftop (VAV)
 - a. Discharge Air Temperature
 - b. Discharge Air Temperature Setpoint Active
 - c. Space Temperature Active
 - d. Cooling Capacity Status

- e. Discharge Air Flow
- 4. Air Handling Unit/Rooftop (CV)
 - a. Discharge Air Temperature
 - b. Space Temperature Active
 - c. Space Temperature Setpoint Active
 - d. Cooling Capacity Status
 - e. Heating Capacity Primary Status
 - f. Outdoor Air Damper Position
- 5. VAV Box
 - a. Discharge Air Temperature
 - b. Space Temperature Active
 - c. Space Temperature Setpoint Active
 - d. Air Flow Setpoint Active
 - e. Discharge Air Flow

16.3 TRIM AND RESPOND

- A. The BAS shall provide a setpoint reset application program based on 'trim and respond' functionality as outlined in ASHRAE Guideline 36.

END OF SECTION

This page intentionally left blank

SECTION 23 1123 - FACILITY NATURAL-GAS PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe, pipe fittings, valves, and connections for natural gas piping systems.

1.2 REFERENCE STANDARDS

- A. ANSI Z223.1 - National Fuel Gas Code 2021.
- B. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators 2023.
- C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- D. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes 2018.
- E. ASME B31.1 - Power Piping 2022.
- F. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- G. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2023a.
- H. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2022.
- I. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- J. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems 2018.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.4 QUALITY ASSURANCE

- A. Perform work in accordance with applicable codes.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- D. Welder Qualifications: Certified in accordance with ASME BPVC-IX.
- E. Identify pipe with marking including size, ASTM material classification, and ASTM specification.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.1 NATURAL GAS PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASTM A234/A234M, wrought steel welding type, with AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.
 - 2. Joints: ASME B31.1, welded.

2.2 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: ANSI Z223.1, welded.
 - 3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2.3 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: Threaded or welded to ASME B31.1.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) or L (B) annealed.
 - 1. Fittings: ASME B16.26, cast bronze.
 - 2. Joints: Flared.

2.4 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:

1. Ferrous pipe: Class 150 malleable iron threaded unions.
 2. Copper tube and pipe: Class 150 bronze unions with soldered joints.
- B. Flanges for Pipe Size Over 1 Inch:
1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
 2. Copper Tube and Pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.

2.5 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
 3. Trapeze Hangers: Welded steel channel frames attached to structure.
 4. Vertical Pipe Support: Steel riser clamp.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that excavations are to required grade, dry, and not over-excavated.

3.2 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

END OF SECTION

This page intentionally left blank

SECTION 23 3100 - HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Metal ductwork.
- B. Nonmetal ductwork.

1.2 REFERENCE STANDARDS

- A. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.

1.3 SUBMITTALS

- A. Product Data: Provide data for duct materials.
- B. Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for medium pressure class and higher systems.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of experience.

PART 2 PRODUCTS

2.1 DUCT ASSEMBLIES

- A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.
- B. Ducts: Galvanized steel, unless otherwise indicated.

2.2 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
- C. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- D. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.

- E. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.
- F. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- G. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
- H. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.3 MANUFACTURED DUCTWORK AND FITTINGS

- A. Double Wall Insulated Round Ducts: Round spiral lockseam duct with galvanized steel outer wall, perforated galvanized steel inner wall; fitting with solid inner wall.
 - 1. Manufacture in accordance with SMACNA (DCS).
- B. Spiral Ducts: Round spiral lockseam duct with galvanized steel outer wall.
 - 1. Manufacture in accordance with SMACNA (DCS).
- C. Round Ducts: Round lockseam duct with galvanized steel outer wall.
 - 1. Manufacture in accordance with SMACNA (DCS).

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install in accordance with manufacturer's instructions.
- C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- E. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- F. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

END OF SECTION

SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Backdraft dampers - metal.
- B. Duct access doors.
- C. Flexible duct connections.
- D. Volume control dampers.

1.2 REFERENCE STANDARDS

- A. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2020.

1.3 SUBMITTALS

- A. Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.
- B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.1 BACKDRAFT DAMPERS - METAL

- A. Gravity Backdraft Dampers, Size 18 by 18 inches or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturer's standard construction.

2.2 BACKDRAFT DAMPERS - FABRIC

- A. Fabric Backdraft Dampers: Factory-fabricated.
 - 1. Blades: Neoprene coated fabric material.
 - 2. Birdscreen: 1/2 inch nominal mesh of galvanized steel or aluminum.
 - 3. Maximum Velocity: 1000 fpm (5 mps) face velocity.

2.3 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Single Blade Dampers:
 - 1. Fabricate for duct sizes up to 6 by 30 inch.
 - 2. Blade: 24 gage, 0.0239 inch, minimum.
- C. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
 - 1. Blade: 18 gage, 0.0478 inch, minimum.

PART 3 EXECUTION

3.1 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 3100 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96 Provide minimum 8 by 8 inch size for hand access, size for shoulder access, and as indicated. Provide 4 by 4 inch for balancing dampers only. Review locations prior to fabrication.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by Authorities Having Jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- F. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- G. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- H. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.

- I. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

END OF SECTION

This page intentionally left blank

SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Roof exhausters.
- B. Ceiling exhaust fans.

1.2 REFERENCE STANDARDS

- A. AMCA 99 - Standards Handbook 2016.

1.3 SUBMITTALS

- A. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.

1.4 QUALITY ASSURANCE

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

1.5 FIELD CONDITIONS

- A. Permanent ventilators may not be used for ventilation during construction.
- B. Permanent ventilators may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

PART 2 PRODUCTS

2.1 POWER VENTILATORS - GENERAL

- A. Fabrication: Comply with AMCA 99.
- B. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.2 ROOF EXHAUSTERS

- A. Fan Unit: Provide equipment as scheduled on sheet M001.
- B. Roof Curb: 8 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.
- C. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.

2.3 CEILING EXHAUST FANS

- A. Centrifugal Fan Unit: Equipment shall be as scheduled on sheet M001
- B. Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.
- C. Grille: Molded white plastic.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.

END OF SECTION

SECTION 23 3700 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Diffusers.
- B. Registers/grilles.

1.2 REFERENCE STANDARDS

- A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating 2012, with Editorial Revision (2015).
- B. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets 2023.
- C. SMACNA (ASMM) - Architectural Sheet Metal Manual 2012.

1.3 SUBMITTALS

- A. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.4 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Test and rate louver performance in accordance with AMCA 500-L.
- C. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.1 RECTANGULAR CEILING DIFFUSERS

- A. Type: Provide as scheduled on sheet M001.

2.2 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Provide as scheduled on sheet M001.
- B. Color: To be selected by Architect/Engineer from manufacturer's standard range.

2.3 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

- A. Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch grid core.
- B. Color: To be selected by Architect/Engineer from manufacturer's standard range.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.
- C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- D. Install diffusers to ductwork with air tight connection.
- E. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9123.

END OF SECTION

SECTION 23 7416 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Packaged, small-capacity, rooftop air-conditioning units.

1.2 RELATED REQUIREMENTS

- A. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

- A. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment 2015, with Addendum (2016).
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2024.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- C. Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- D. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect units from physical damage by storing off site until roof mounting curbs are in place and ready for immediate installation of units.

1.7 WARRANTY

- A. Provide a five year warranty to include coverage for refrigeration compressors.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Trane, a brand of Ingersoll Rand: www.trane.com/#sle.

2.2 PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. General: Roof mounted units having gas burner and electric refrigeration that are 6 tons and smaller in capacity.
- B. Description: Provide equipment as scheduled on sheet M001.
- C. Disconnect Switch: Factory mount disconnect switch in control panel.

2.3 AIR FILTERS:

2.4 OPERATING CONTROLS - VARIABLE VOLUME UNITS

- A. Temperature transmitter located in supply air to signal electronic logic panel to control mixing dampers and cooling in sequence. Mixing section to operate as first stage of cooling and revert to minimum outside air above approximately 75 degrees F as determined by enthalpy of return and outdoor air.
- B. Control cooling by cycling compressors, cylinder unloading, and hot gas bypass.
- C. Control logic to allow supply air reset under low load or airflow conditions.

2.5 ROOF CURBS

- A. Roof Mounting Curb: 14 inches high, galvanized steel, channel frame with gaskets, nailer strips.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that roof is ready to receive work and opening dimensions are as required by manufacturer.
- B. Verify that proper power supply is available.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA 90A.
- C. Mount units on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

3.3 SYSTEM STARTUP

- A. Prepare and start equipment. Adjust for proper operation.

3.4 CLOSEOUT ACTIVITIES

- A. Demonstrate proper operation of equipment to Owner's designated representative.

END OF SECTION

This page intentionally left blank

SECTION 23 8150 - DUCTLESS SPLIT SYSTEM UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The work required under this section includes all work necessary for the complete installation of ductless split system units.
- B. The work of this section is subject to the requirements of the Mechanical General Provisions and Basic Material Specifications.

1.2 RELATED WORK ELSEWHERE

- A. HVAC Basic Materials & Methods, Section 23-05-00
- B. Insulation, Section 23-07-00
- C. Refrigerant Piping, Section 23-23-30.

1.3 SUBMITTALS

- A. Provide drawings indicating dimensions, rough-in connections, electrical characteristics, unit performance, agency listings, and connection requirements.
- B. Provide manufacturer's installation and start-up instructions.
- C. Provide manufacturer's color selection charts.
- D. At job closeout, provide manufacturer's installation, operation, and maintenance data along with product warranty certificate.

1.4 WARRANTY

- A. Provide one year warranty on all unit parts and a five year warranty for refrigeration compressors.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Furnish and install where shown on plans, ductless split system units of sizes and capacities shown on the schedule. The units shall include the indoor evaporator section and the outdoor condenser section. Approved manufacturers shall be EMI, Mitsubishi, and Liebert.

2.2 WALL HUNG EVAPORATOR SECTION

- A. Provide wall hung AC units with back-up as scheduled on M001. Provide hanger brackets and or trim kits as applicable.
- B. Cabinet shall be constructed of cold roll steel, with structural stiffeners and powder coated finish. Inlet panel construction of high impact polystyrene with perforated steel inlet grille.

- C. Discharge grille shall be high temperature Noryl with adjustable vanes.
- D. Condensate drain pan shall be galvanized steel with anti-corrosion coating.
- E. Filter shall be permanent, washable, and user accessible.
- F. Coil shall be seamless copper tubing, arranged in staggered configuration, with enhanced aluminum fins, tested to 460 PSIG. Tubes shall be mechanically expanded for secure bonding to fin shoulder. Connections are sweat type.

2.3 CONDENSER SECTION

- A. Provide a single zone condensing unit as scheduled on sheet M001.
- B. Cabinet shall be constructed of G-60 galvanized steel, finished with corrosion inhibiting, high-gloss, powder coated. Fan guard shall be heavy-gauge, vinyl dipped wire, or stamped integral to cabinet.
- C. The condensing unit and evaporator section shall be precharged with R-410A refrigerant. Unit refrigeration valves shall be solid brass for sweat connection.
- D. The condenser coil shall be seamless, copper tubing, arranged in staggered configuration, with enhanced aluminum fins. The tubes shall be mechanically expanded for secure bonding to fin shoulder.
- E. The condenser fan shall be a high efficiency propeller type, directly connected to the totally enclosed PSC motor. The motor shall be internally and thermally protected. The condensing unit shall be draw-through design.
- F. System options shall include low ambient operation to 0 degrees F. Other system options shall be as noted on schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install unit in accordance with manufacturer's recommendations.
- B. Verify prior to bidding that all units meet all electrical characteristics shown in the contract documents. This shall include voltage, phase, full load amps, and overcurrent protection. Coordinate exact electrical requirements with the electrical contractor prior to rough-in.

END OF SECTION

SECTION 23 8200 - CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electric unit heaters.

1.2 SUBMITTALS

- A. Product Data: Provide typical catalog of information including arrangements.
- B. Shop Drawings:
 - 1. Indicate air coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.4 WARRANTY

- A. Provide 5 year manufacturer's warranty for _____.

PART 2 PRODUCTS

2.1 ELECTRIC UNIT HEATERS

- A. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- B. Provide equipment as scheduled on sheet M001.
- C. Controls:
 - 1. Disconnect.
 - 2. Built-in thermostat.
- D. Electrical Characteristics:
 - 1. Disconnect Switch: Factory mount disconnect switch.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are suitable for installation.
- B. Verify that field measurements are as indicated on drawings.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.
- C. Do not damage equipment or finishes.
- D. Ceiling Unit Heaters:
 - 1. Install as indicated.
 - 2. Coordinate to ensure correct recess size for recessed units.

3.3 CLEANING

- A. After construction and painting is completed, clean exposed surfaces of units.
- B. Vacuum clean coils and inside of units.
- C. Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.

3.4 PROTECTION

- A. Provide finished cabinet units with protective covers during the balance of construction.

END OF SECTION

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Single conductor building wire.
- B. Metal-clad cable.
- C. Wiring connectors.
- D. Electrical tape.
- E. Heat shrink tubing.
- F. Oxide inhibiting compound.
- G. Wire pulling lubricant.
- H. Cable ties.

1.2 RELATED REQUIREMENTS

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- B. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- C. Section 28 4600 - Fire Detection and Alarm: Fire alarm system conductors and cables.
- D. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.
- E. Section 31 2323 - Fill: Bedding and backfilling.

1.3 REFERENCE STANDARDS

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire 2013 (Reapproved 2018).
- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft 2011 (Reapproved 2017).
- C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes 2010, with Editorial Revision (2020).
- D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation 2004 (Reapproved 2020).
- E. ASTM B800 - Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes - Annealed and Intermediate Tempers 2005 (Reapproved 2021).

- F. ASTM B801 - Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation 2018.
- G. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape 2017.
- H. ASTM D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes 2020.
- I. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- J. NECA 104 - Standard for Installing Aluminum Building Wire and Cable 2012.
- K. NECA 120 - Standard for Installing Armored Cable (AC) and Type Metal-Clad (MC) Cable 2018.
- L. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy 2021.
- M. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- N. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.
- O. UL 44 - Thermoset-Insulated Wires and Cables Current Edition, Including All Revisions.
- P. UL 83 - Thermoplastic-Insulated Wires and Cables Current Edition, Including All Revisions.
- Q. UL 486A-486B - Wire Connectors Current Edition, Including All Revisions.
- R. UL 486C - Splicing Wire Connectors Current Edition, Including All Revisions.
- S. UL 486D - Sealed Wire Connector Systems Current Edition, Including All Revisions.
- T. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape Current Edition, Including All Revisions.
- U. UL 854 - Service-Entrance Cables Current Edition, Including All Revisions.
- V. UL 1277 - Electrical Power and Control Tray Cables with Optional Optical-Fiber Members Current Edition, Including All Revisions.
- W. UL 1569 - Metal-Clad Cables Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.

2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
3. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

1.7 FIELD CONDITIONS

- A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Architect/Engineer and obtain direction before proceeding with work.

PART 2 PRODUCTS

2.1 CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
- C. Nonmetallic-sheathed cable is not permitted.
- D. Armored cable is not permitted.
- E. Metal-clad cable is permitted only as follows:
 1. Where not otherwise restricted, may be used:
 - a. Luminaires: Where concealed above accessible ceilings for final connections from junction boxes to luminaires.
 - 1) Maximum Length: 6 feet.
 - b. Receptacles: Where concealed in hollow stud walls, above accessible ceilings, and under raised floors for branch circuits up to 20 A.

- 1) Exception: Provide single conductor building wire in raceway for circuit homerun from first outlet to panelboard.
 2. In addition to other applicable restrictions, may not be used:
 - a. Where not approved for use by the authority having jurisdiction.
 - b. Where exposed to view.
 - c. Where exposed to damage.
 - d. For damp, wet, or corrosive locations, unless provided with a PVC jacket listed as suitable for those locations.
- F. Manufactured wiring systems are not permitted.

2.2 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Provide new conductors and cables manufactured not more than one year prior to installation.
- D. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- E. Comply with NEMA WC 70.
- F. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- G. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- H. Conductors for Grounding and Bonding: Also comply with Section 26 0526.
- I. Conductor Material:
 1. Provide copper conductors except where aluminum conductors are specifically indicated or permitted for substitution. Conductor sizes indicated are based on copper unless specifically indicated as aluminum. Conductors designated with the abbreviation "AL" indicate aluminum.
 - a. Substitution of aluminum conductors for copper is permitted, when approved by Owner and authority having jurisdiction, only for the following:
 - 1) Services: Copper conductors size 1/0 AWG and larger.
 - 2) Feeders: Copper conductors size 1/0 AWG and larger.
 - b. Where aluminum conductors are substituted for copper, comply with the following:

- 1) Size aluminum conductors to provide, when compared to copper sizes indicated, equivalent or greater ampacity and equivalent or less voltage drop.
 - 2) Increase size of raceways, boxes, wiring gutters, enclosures, etc. as required to accommodate aluminum conductors.
 - 3) Provide aluminum equipment grounding conductor sized according to NFPA 70.
 - 4) Equip electrical distribution equipment with compression lugs for terminating aluminum conductors.
2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
 3. Tinned Copper Conductors: Comply with ASTM B33.
 4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.
- J. Minimum Conductor Size:
1. Branch Circuits: 12 AWG.
 2. Control Circuits: 14 AWG.
- K. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- L. Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
 2. Color Coding Method: Integrally colored insulation.
 - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
 3. Color Code:
 - a. 208Y/120 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral/Grounded: White.

- b. Equipment Ground, All Systems: Green.
- c. Travelers for 3-Way and 4-Way Switching: Pink.
- d. For control circuits, comply with manufacturer's recommended color code.

2.3 SINGLE CONDUCTOR BUILDING WIRE

- A. Description: Single conductor insulated wire.
- B. Conductor Stranding:
 - 1. Feeders and Branch Circuits:
 - a. Size 10 AWG and Smaller: Solid.
 - b. Size 8 AWG and Larger: Stranded.
 - 2. Control Circuits: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation:
 - 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.
 - a. Installed Underground: Type XHHW-2.
 - b. Fixture Wiring Within Luminaires: Type TFFN/TFN for luminaires with labeled maximum temperature of 90 degrees C; Approved suitable type for luminaires with labeled maximum temperature greater than 90 degrees C.
 - 2. Aluminum Building Wire (only where specifically indicated or permitted for substitution): Type XHHW-2.

2.4 METAL-CLAD CABLE

- A. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- B. Conductor Stranding:
 - 1. Size 10 AWG and Smaller: Solid.
 - 2. Size 8 AWG and Larger: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation: Type THHN/THWN or THHN/THWN-2.
- E. Provide oversized neutral conductors where indicated or required.
- F. Provide dedicated neutral conductor for each phase conductor where indicated or required.

- G. Grounding: Full-size integral equipment grounding conductor.
- H. Armor: Aluminum or steel, interlocked tape.
- I. Provide PVC jacket applied over cable armor where indicated or required for environment of installed location.

2.5 WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Connectors for Grounding and Bonding: Comply with Section 26 0526.
- C. Wiring Connectors for Splices and Taps:
 - 1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
 - 2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors.
 - 3. Connectors for Aluminum Conductors: Use mechanical connectors.
- D. Wiring Connectors for Terminations:
 - 1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
 - 2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.
 - 3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
 - 4. Provide motor pigtail connectors for connecting motor leads in order to facilitate disconnection.
 - 5. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors for all connections.
 - 6. Aluminum Conductors: Use mechanical connectors for all connections.
 - 7. Stranded Conductors Size 10 AWG and Smaller: Use crimped terminals for connections to terminal screws.
 - 8. Conductors for Control Circuits: Use crimped terminals for all connections.
- E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

- G. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.
- H. Mechanical Connectors: Provide bolted type.
- I. Crimped Terminals: Nylon-insulated, with insulation grip and terminal configuration suitable for connection to be made.

2.6 WIRING ACCESSORIES

A. Electrical Tape:

1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
 2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
 3. Rubber Splicing Electrical Tape: Ethylene Propylene Rubber (EPR) tape, complying with ASTM D4388; minimum thickness of 30 mil; suitable for continuous temperature environment up to 194 degrees F and short-term 266 degrees F overload service.
 4. Electrical Filler Tape: Rubber-based insulating moldable putty, minimum thickness of 125 mil; suitable for continuous temperature environment up to 176 degrees F.
 5. Varnished Cambric Electrical Tape: Cotton cambric fabric tape, with or without adhesive, oil-primed and coated with high-grade insulating varnish; minimum thickness of 7 mil; suitable for continuous temperature environment up to 221 degrees F.
 6. Moisture Sealing Electrical Tape: Insulating mastic compound laminated to flexible, all-weather vinyl backing; minimum thickness of 90 mil.
- B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.
- C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
- D. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.
- E. Cable Ties: Material and tensile strength rating suitable for application.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.3 INSTALLATION

- A. Circuiting Requirements:
 - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
 - 2. When circuit destination is indicated without specific routing, determine exact routing required.
 - 3. Arrange circuiting to minimize splices.
 - 4. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
 - 5. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
 - 6. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
 - a. Provide no more than six current-carrying conductors in a single raceway. Dedicated neutral conductors are considered current-carrying conductors.
 - 7. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among up to three single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
 - a. Branch circuits fed from ground fault circuit interrupter (GFCI) circuit breakers.
 - b. Branch circuits fed from feed-through protection of GFI receptacles.
 - c. Branch circuits with dimming controls.
- B. Install products in accordance with manufacturer's instructions.
- C. Perform work in accordance with NECA 1 (general workmanship).

- D. Install aluminum conductors in accordance with NECA 104.
- E. Install metal-clad cable (Type MC) in accordance with NECA 120.
- F. Installation in Raceway:
 - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
 - 2. Pull all conductors and cables together into raceway at same time.
 - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- G. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- H. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
 - 1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
 - 2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.
- I. Terminate cables using suitable fittings.
 - 1. Metal-Clad Cable (Type MC):
 - a. Use listed fittings.
 - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
 - c. Do not use direct-bearing set-screw type fittings for cables with aluminum armor.
- J. Install conductors with a minimum of 12 inches of slack at each outlet.
- K. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.
- L. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

- M. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- N. Make wiring connections using specified wiring connectors.
1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies.
 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 3. Do not remove conductor strands to facilitate insertion into connector.
 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
 5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
 6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- O. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
1. Dry Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
 - a. For taped connections, first apply adequate amount of rubber splicing electrical tape or electrical filler tape, followed by outer covering of vinyl insulating electrical tape.
 - b. For taped connections likely to require re-entering, including motor leads, first apply varnished cambric electrical tape, followed by adequate amount of rubber splicing electrical tape, followed by outer covering of vinyl insulating electrical tape.
 2. Damp Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
 - a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
 - b. For taped connections, follow same procedure as for dry locations but apply outer covering of moisture sealing electrical tape.
 3. Wet Locations: Use heat shrink tubing.
- P. Insulate ends of spare conductors using vinyl insulating electrical tape.

- Q. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- R. Identify conductors and cables in accordance with Section 26 0553.
- S. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.
 - 1. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

END OF SECTION

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground rod electrodes.
- E. Ground access wells.

1.2 RELATED REQUIREMENTS

- A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- B. Section 26 0536 - Cable Trays for Electrical Systems: Additional grounding and bonding requirements for cable tray systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 5600 - Exterior Lighting: Additional grounding and bonding requirements for pole-mounted luminaires.

1.3 REFERENCE STANDARDS

- A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System 2012.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings 2022.
- D. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- E. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.
- F. UL 467 - Grounding and Bonding Equipment Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify exact locations of underground metal water service pipe entrances to building.

2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode located in the building footings.
 3. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING REQUIREMENTS

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- D. Grounding System Resistance:
1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Architect/Engineer. Precipitation within the previous 48 hours does not constitute normally dry conditions.
 2. Grounding Electrode System: Not greater than 25 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
- E. Grounding Electrode System:
1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - a. Provide continuous grounding electrode conductors without splice or joint.

- b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
- 2. Metal Underground Water Pipe(s):
 - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
 - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
 - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
- 3. Concrete-Encased Electrode:
 - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
- 4. Ground Rod Electrode(s):
 - a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
 - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
 - c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
 - d. Provide ground access well for first connected electrode.
- 5. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
- 6. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
 - a. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
 - b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.

- c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
- 7. Ground Riser: Provide common grounding electrode conductor not less than 2/0 AWG for tap connections to multiple separately derived systems as permitted in NFPA 70.
- F. Service-Supplied System Grounding:
 - 1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
 - 2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.
- G. Bonding and Equipment Grounding:
 - 1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
 - 2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as equipment grounding conductor.
 - 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
 - 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
 - 5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
 - 6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
 - 7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
 - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
 - b. Metal gas piping.
 - 8. Provide bonding for metal building frame.

2.2 GROUNDING AND BONDING COMPONENTS

A. General Requirements:

1. Provide products listed, classified, and labeled as suitable for the purpose intended.
2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 0526:

1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:
 - 1) Use bare copper conductors where installed underground in direct contact with earth.
 - 2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:

1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
 - a. Exceptions:
 - 1) Use mechanical connectors for connections to electrodes at ground access wells.
3. Unless otherwise indicated, use mechanical connectors for accessible connections.
 - a. Exceptions:
 - 1) Use exothermic welded connections for connections to metal building frame.

D. Ground Bars:

1. Description: Copper rectangular ground bars with mounting brackets and insulators.
2. Size: 1/4"x4"x12" unless otherwise indicated or required.
3. Holes for Connections: As indicated or as required for connections to be made.

E. Ground Rod Electrodes:

1. Comply with NEMA GR 1.
2. Material: Copper-bonded (copper-clad) steel.

3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
4. Where rod lengths of greater than 10 feet are indicated or otherwise required, sectionalized ground rods may be used.

F. Ground Access Wells:

1. Description: Open bottom round or rectangular well with access cover for testing and inspection; suitable for the expected load at the installed location.
 - a. Areas Exposed to Regular Vehicular Traffic: Rated for not less than 16,000 pounds vertical design load.
2. Size: As required to provide adequate access for testing and inspection, but not less than minimum size requirements specified.
 - a. Round Wells: Not less than 8 inches in diameter.
3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 10 inches.
4. Cover: Factory-identified by permanent means with word "GROUND".

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70.
 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
- D. Make grounding and bonding connections using specified connectors.
 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.

2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Perform inspection, testing, and adjusting in accordance with Section 01 4000.
- C. Inspect and test in accordance with NETA ATS except Section 4.
- D. Perform inspections and tests listed in NETA ATS, Section 7.13.
- E. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- F. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.
- G. Submit detailed reports indicating inspection and testing results and corrective actions taken.

END OF SECTION

This page intentionally left blank

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 0533.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.
- C. Section 26 0536 - Cable Trays for Electrical Systems: Additional support and attachment requirements for cable tray.
- D. Section 26 0533.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.
- E. Section 26 5100 - Interior Lighting: Additional support and attachment requirements for interior luminaires.
- F. Section 26 5600 - Exterior Lighting: Additional support and attachment requirements for exterior luminaires.

1.3 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2023.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2023.
- D. MFMA-4 - Metal Framing Standards Publication 2004.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- F. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.

2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 3000.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with applicable building code.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 125%. Include consideration for vibration, equipment operation, and shock loads where applicable.
 4. Do not use products for applications other than as permitted by NFPA 70 and product listing.

5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
6. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
- D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 1. Comply with MFMA-4.
 2. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 3. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch.
 4. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
- E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Single Conduit up to 1 inch (27 mm) trade size: 1/4 inch diameter.
 - c. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter.

d. Trapeze Support for Multiple Conduits: 3/8 inch diameter.

e. Outlet Boxes: 1/4 inch diameter.

f. Luminaires: 1/4 inch diameter.

F. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Sheet Metal: Use sheet metal screws.
8. Wood: Use wood screws.
9. Plastic and lead anchors are not permitted.
10. Powder-actuated fasteners are not permitted.
11. Hammer-driven anchors and fasteners are not permitted.
12. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch minimum base metal thickness.
 - d. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Architect/Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect/Engineer, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
 - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.
 - 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Conduit Support and Attachment: Also comply with Section 26 0533.13.
- I. Cable Tray Support and Attachment: Also comply with Section 26 0536.
- J. Box Support and Attachment: Also comply with Section 26 0533.16.
- K. Interior Luminaire Support and Attachment: Also comply with Section 26 5100.
- L. Exterior Luminaire Support and Attachment: Also comply with Section 26 5600.
- M. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- N. Secure fasteners according to manufacturer's recommended torque settings.
- O. Remove temporary supports.

- P. Identify independent electrical component support wires above accessible ceilings (only where specifically indicated or permitted) with color distinguishable from ceiling support wires in accordance with NFPA 70.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 26 0533.13 - CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Intermediate metal conduit (IMC).
- C. Flexible metal conduit (FMC).
- D. Liquidtight flexible metal conduit (LFMC).
- E. Electrical metallic tubing (EMT).
- F. Rigid polyvinyl chloride (PVC) conduit.
- G. Conduit fittings.
- H. Accessories.

1.2 RELATED REQUIREMENTS

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems.
 - 1. Includes additional requirements for fittings for grounding and bonding.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 31 2316 - Excavation.
- E. Section 31 2323 - Fill: Bedding and backfilling.

1.3 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC) 2020.
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S) 2020.
- C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit 2018.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT) 2020.
- F. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC) 2017.
- G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.

- H. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit 2020.
- I. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing 2021.
- J. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.
- K. UL 1 - Flexible Metal Conduit Current Edition, Including All Revisions.
- L. UL 6 - Electrical Rigid Metal Conduit-Steel Current Edition, Including All Revisions.
- M. UL 360 - Liquid-Tight Flexible Metal Conduit Current Edition, Including All Revisions.
- N. UL 514B - Conduit, Tubing, and Cable Fittings Current Edition, Including All Revisions.
- O. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings Current Edition, Including All Revisions.
- P. UL 797 - Electrical Metallic Tubing-Steel Current Edition, Including All Revisions.
- Q. UL 1242 - Electrical Intermediate Metal Conduit-Steel Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
 - 4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
 - 5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
 - 1. Under Slab on Grade: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or rigid PVC conduit.
 - 2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit, intermediate metallic conduit (IMC), or rigid PVC conduit.
 - 3. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit or rigid PVC conduit.
 - 4. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
 - 5. Where rigid polyvinyl (PVC) conduit larger than 2 inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit elbows for bends.
 - 6. Where steel conduit is installed in direct contact with earth where soil has a resistivity of less than 2000 ohm-centimeters or is characterized as severely corrosive based on soils report or local experience, use corrosion protection tape to provide supplementary corrosion protection.
 - 7. Where steel conduit emerges from concrete into soil, use corrosion protection tape to provide supplementary corrosion protection for a minimum of 4 inches on either side of where conduit emerges.
- D. Embedded Within Concrete:
 - 1. Within Slab on Grade: Not permitted.
 - 2. Within Slab Above Ground: Not permitted.
 - 3. Within Concrete Walls Above Ground: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or rigid PVC conduit.

- E. Concealed Within Masonry Walls: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
- F. Concealed Within Hollow Stud Walls: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
- G. Concealed Above Accessible Ceilings: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
- H. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.
- I. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
- J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit.
 - 1. Locations subject to physical damage include, but are not limited to:
 - a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
 - b. Where exposed in parking garage and alley port.
- K. Exposed, Exterior: Use galvanized steel rigid metal conduit.
- L. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit.
- M. Connections to Luminaires Above Accessible Ceilings: Use MC Cable.
 - 1. Maximum Length: 6 feet.
- N. Connections to Vibrating Equipment:
 - 1. Dry Locations: Use flexible metal conduit.
 - 2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
 - 3. Maximum Length: 6 feet unless otherwise indicated.
 - 4. Vibrating equipment includes, but is not limited to:
 - a. Transformers.
 - b. Motors.

2.2 CONDUIT REQUIREMENTS

- A. Fittings for Grounding and Bonding: Also comply with Section 26 0526.
- B. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.

- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Branch Circuits: 3/4 inch (21 mm) trade size.
 - 2. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.
 - 3. Control Circuits: 1/2 inch (16 mm) trade size.
 - 4. Flexible Connections to Luminaires: 1/2 inch (16 mm) trade size.
 - 5. Underground, Interior: 3/4 inch (21 mm) trade size.
 - 6. Underground, Exterior: 1 1/2 inch (41 mm) trade size.
 - 7. Communication, Interior: 1 inch (27mm).
- E. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.3 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B. Fittings:
 - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.4 INTERMEDIATE METAL CONDUIT (IMC)

- A. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B. Fittings:
 - 1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.

3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.5 FLEXIBLE METAL CONDUIT (FMC)

- A. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.
- B. Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.

2.6 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- B. Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.

2.7 ELECTRICAL METALLIC TUBING (EMT)

- A. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- B. Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel or malleable iron.
 3. Connectors and Couplings: Use set-screw type.
 - a. Do not use indenter type connectors and couplings.

2.8 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

- A. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 in non-traffic areas and schedule 80 in traffic areas rated for use with conductors rated 90 degrees C.

B. Fittings:

1. Manufacturer: Same as manufacturer of conduit to be connected.
2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.9 ACCESSORIES

- A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.
- B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.
- C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.
- E. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.
- F. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive conduits.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install intermediate metal conduit (IMC) in accordance with NECA 101.
- E. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- F. Conduit Routing:
 1. Unless dimensioned, conduit routing indicated is diagrammatic.
 2. When conduit destination is indicated without specific routing, determine exact routing required.

3. Conceal all conduits unless specifically indicated to be exposed.
 4. Conduits in the following areas may be exposed, unless otherwise indicated:
 - a. Electrical rooms.
 - b. Mechanical equipment rooms.
 - c. Within joists in areas with no ceiling.
 5. Unless otherwise approved, do not route conduits exposed:
 - a. Across floors.
 - b. Across roofs.
 - c. Across top of parapet walls.
 - d. Across building exterior surfaces.
 6. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
 7. Arrange conduit to maintain adequate headroom, clearances, and access.
 8. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
 9. Arrange conduit to provide no more than 100 feet between pull points.
 10. Route conduits above water and drain piping where possible.
 11. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
 12. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
 13. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
 - a. Heaters.
 - b. Hot water piping.
 - c. Flues.
 14. Group parallel conduits in the same area together on a common rack.
- G. Conduit Support:

1. Secure and support conduits in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
4. Use conduit strap to support single surface-mounted conduit.
 - a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
6. Use conduit clamp to support single conduit from beam clamp or threaded rod.
7. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
8. Use of spring steel conduit clips for support of conduits is not permitted.
9. Use of wire for support of conduits is not permitted.
10. Where conduit support intervals specified in NFPA 70 and NECA standards differ, comply with the most stringent requirements.

H. Connections and Terminations:

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
6. Where spare conduits stub up through concrete floors and are not terminated in a box or enclosure, provide threaded couplings equipped with threaded plugs set flush with finished floor.
7. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.

8. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
9. Provide temporary conduit caps until conductors are installed or conduits are terminated.

I. Penetrations:

1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
4. Conceal bends for conduit risers emerging above ground.
5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
6. Provide suitable modular seal where conduits penetrate exterior wall below grade.
7. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
8. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
9. Provide metal escutcheon plates for conduit penetrations exposed to public view.

J. Underground Installation:

1. Provide trenching and backfilling in accordance with Section 31 2316 and Section 31 2323.
2. Minimum Cover, Unless Otherwise Indicated or Required (600Volt or less):
 - a. Underground, Exterior: 24 inches.
 - b. Under Slab on Grade: 12 inches to bottom of slab.
3. Minimum Cover, Unless Otherwise Indicated or Required (above 600Volt):
 - a. Underground, Exterior: 42 inches.
4. Provide underground warning tape in accordance with Section 26 0553 along entire conduit length.

- K. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
 - 1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
 - 2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
 - 3. Where conduits are subject to earth movement by settlement or frost.
- L. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
 - 1. Where conduits pass from outdoors into conditioned interior spaces.
 - 2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
 - 3. Where conduits penetrate coolers or freezers.
- M. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- N. Provide grounding and bonding in accordance with Section 26 0526.
- O. Identify conduits in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective conduits.

3.4 CLEANING

- A. Clean interior of conduits to remove moisture and foreign matter.

3.5 PROTECTION

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

This page intentionally left blank

SECTION 26 0533.16 - BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Boxes and enclosures for integrated power, data, and audio/video.
- D. Floor boxes.
- E. Underground boxes/enclosures.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- C. Section 26 0529 - Hangers and Supports for Electrical Systems.
- D. Section 26 0533.13 - Conduit for Electrical Systems:
 - 1. Conduit bodies and other fittings.
 - 2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.
- E. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 26 2726 - Wiring Devices:
 - 1. Wall plates.
 - 2. Floor box service fittings.
 - 3. Additional requirements for locating boxes for wiring devices.

1.3 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.

- D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports 2013 (Reaffirmed 2020).
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.
- G. SCTE 77 - Specifications for Underground Enclosure Integrity 2017.
- H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- J. UL 508A - Industrial Control Panels Current Edition, Including All Revisions.
- K. UL 514A - Metallic Outlet Boxes Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
 - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
 - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
 - 6. Coordinate the work with other trades to preserve insulation integrity.
 - 7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
 - 8. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.

- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 BOXES

- A. General Requirements:
 - 1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
 - 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
 - 3. Provide products listed, classified, and labeled as suitable for the purpose intended.
 - 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
 - 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
 - 1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
 - 2. Use cast iron boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
 - 3. Use cast iron boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
 - 4. Use suitable concrete type boxes where flush-mounted in concrete.
 - 5. Use suitable masonry type boxes where flush-mounted in masonry walls.
 - 6. Use raised covers suitable for the type of wall construction and device configuration where required.
 - 7. Use shallow boxes where required by the type of wall construction.
 - 8. Do not use "through-wall" boxes designed for access from both sides of wall.
 - 9. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.

10. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
 11. Boxes for Supporting Luminaires: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
 12. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
 13. Minimum Box Size, Unless Otherwise Indicated:
 - a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.
 - b. Communications Systems Outlets: 4 inch square by 2-1/8 inch (100 by 54 mm) trade size.
 - c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
 14. Wall Plates: Comply with Section 26 2726.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
 2. NEMA 250 Environment Type, Unless Otherwise Indicated:
 - a. Indoor Clean, Dry Locations: Type 1, painted steel.
 - b. Outdoor Locations: Type 3R, painted steel.
 3. Junction and Pull Boxes Larger Than 100 cubic inches:
 - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 - b. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.
 4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
 - a. Provide lockable hinged covers, all locks keyed alike unless otherwise indicated.
 - b. Back Panels: Painted steel, removable.
 - c. Terminal Blocks: Provide voltage/current ratings and terminal quantity suitable for purpose indicated, with 25 percent spare terminal capacity.
 5. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.

- D. Boxes and Enclosures for Integrated Power, Data, and Audio/Video: Size and configuration as indicated or as required with partitions to separate services; field-connected gangable boxes may not be used.
- E. Floor Boxes:
 - 1. Description: Floor boxes compatible with floor box service fittings provided in accordance with Section 26 2726; with partitions to separate multiple services; furnished with all components, adapters, and trims required for complete installation.
 - 2. Use cast iron floor boxes within slab on grade.
 - 3. Use sheet-steel or cast iron floor boxes within slab above grade.
 - 4. Metallic Floor Boxes: Fully adjustable (with integral means for leveling adjustment prior to and after concrete pour).
 - 5. Manufacturer: Same as manufacturer of floor box service fittings.
- F. Underground Boxes/Enclosures:
 - 1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
 - 2. Size: As indicated on drawings.
 - 3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 12 inches.
 - 4. Provide logo on cover to indicate type of service.
 - 5. Applications:
 - a. Sidewalks and Landscaped Areas Subject Only to Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 8 load rating.
 - b. Parking Lots, in Areas Subject Only To Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 15 load rating.
 - c. Do not use polymer concrete enclosures in areas subject to deliberate vehicular traffic.
 - 6. Polymer Concrete Underground Boxes/Enclosures: Comply with SCTE 77.
 - a. Combination fiberglass/polymer concrete boxes/enclosures are acceptable.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.

- B. Verify that mounting surfaces are ready to receive boxes.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- H. Box Locations:
 - 1. Locate boxes to be accessible.
 - 2. Unless dimensioned, box locations indicated are approximate.
 - 3. Locate boxes as required for devices installed under other sections or by others.
 - a. Switches, Receptacles, and Other Wiring Devices: Comply with Section 26 2726.
 - 4. Locate boxes so that wall plates do not span different building finishes.
 - 5. Locate boxes so that wall plates do not cross masonry joints.
 - 6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
 - 7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
 - 8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.
 - 9. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 0533.13.

10. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
 - a. Concealed above accessible suspended ceilings.
 - b. Within joists in areas with no ceiling.
 - c. Electrical rooms.
 - d. Communication rooms.
- I. Box Supports:
 1. Secure and support boxes in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
 2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
 3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
 4. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.
- J. Install boxes plumb and level.
- K. Flush-Mounted Boxes:
 1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
 2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
 3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- L. Floor-Mounted Cabinets: Mount on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.
- M. Install boxes as required to preserve insulation integrity.
- N. Metallic Floor Boxes: Install box level at the proper elevation to be flush with finished floor.
- O. Underground Boxes/Enclosures:
 1. Install enclosure on gravel base, minimum 6 inches deep.

2. Flush-mount enclosures located in concrete or paved areas.
 3. Mount enclosures located in landscaped areas with top at 1 inch above finished grade.
 4. Provide cast-in-place concrete collar constructed in accordance with Section 03 3000, minimum 10 inches wide by 12 inches deep, around enclosures that are not located in concrete areas.
 5. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.
- P. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- Q. Close unused box openings.
- R. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- S. Provide grounding and bonding in accordance with Section 26 0526.
- T. Identify boxes in accordance with Section 26 0553.

3.3 CLEANING

- A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

3.4 PROTECTION

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION

SECTION 26 0536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Metal cable tray systems:
 - 1. Metal ladder cable tray.
 - 2. Metal wire mesh/basket cable tray.

1.2 RELATED REQUIREMENTS

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.3 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2023.
- C. ASTM A780/A780M - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings 2020.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- E. NEMA VE 1 - Metal Cable Tray Systems 2017.
- F. NEMA VE 2 - Cable Tray Installation Guidelines 2018.
- G. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the arrangement of cable tray with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others. Coordinate the work with other trades to avoid installation of obstructions within cable tray required clearances.
 - 2. Coordinate arrangement of cable tray with the dimensions and clearance requirements of the actual products to be installed.
 - 3. Coordinate the work with placement of supports, anchors, etc. required for mounting.

4. Notify of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week prior to commencing work of this section; require attendance of all affected installers. Review proposed routing, sequence of installation, and protection requirements for installed cable tray.
- C. Sequencing:
 1. Do not begin installation of cables until installation of associated cable tray run is complete.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cable tray system components and accessories. Include dimensions, materials, fabrication details, finishes, and span/load ratings.
- C. Shop Drawings: Include dimensioned plan views and sections indicating proposed cable tray routing, required clearances, and locations and details of supports, fittings, building element penetrations, and equipment connections.
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Project Record Documents: Record actual routing of cable tray and locations of supports.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions and NEMA VE 2, except do not store cable tray outdoors without cover as permitted in NEMA VE 2.
- B. Handle products carefully to avoid damage to finish.

PART 2 PRODUCTS

2.1 CABLE TRAY SYSTEM - GENERAL REQUIREMENTS

- A. Provide new cable tray system consisting of all required components, fittings, supports, accessories, etc. as necessary for a complete system.

- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use cable tray for applications other than as permitted by NFPA 70 and product listing/classification.
- D. Provide cable tray system and associated components suitable for use at indicated span/load ratings under the service conditions at the installed location.
- E. Unless otherwise indicated, specified span/load ratings are according to NEMA VE 1 (metal cable tray systems) with safety factor of 1.5 and working load only (no additional concentrated static load).
- F. Unless otherwise indicated, specified load/fill depths and inside widths are nominal values according to NEMA VE 1 (metal cable tray systems) with applicable allowable tolerances.

2.2 METAL CABLE TRAY SYSTEMS

- A. Comply with NEMA VE 1.
- B. Finishes:
 - 1. Hot-Dip Galvanized After Fabrication (H.D.G.A.F.) Steel: Comply with ASTM A123/A123M.
- C. Metal Ladder Cable Tray (IT Closets):
 - 1. Material: Hot-dip galvanized after fabrication (H.D.G.A.F.) steel.
 - 2. Side Rail Construction: I-beam, C-channel flange out, or C-channel flange in.
 - 3. Load/Fill Depth: 4 inches.
 - 4. Span/Load Rating: NEMA VE 1 Class 8C.
 - 5. Rung Spacing: 6 inches on center for straight lengths.
 - 6. Inside Width: As indicated on drawings.
 - 7. Inside Radius of Fittings: 12 inches.
- D. Metal Wire Mesh/Basket Cable Tray (Corridors):
 - 1. Material: Hot-dip galvanized after fabrication (H.D.G.A.F.) steel.
 - 2. Tray Depth: 4 inches.
 - 3. Span/Load Rating: NEMA VE 1 Class 8C.
 - 4. Mesh Spacing: 2 by 4 inches.
 - 5. Tray Width: As indicated on drawings.

2.3 SOURCE QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Metal Cable Tray: Perform factory design tests in accordance with NEMA VE 1, including electrical continuity and load testing.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that work likely to damage cable tray system has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that the dimensions and span/load ratings of cable tray system components are consistent with the indicated requirements.
- D. Verify that mounting surfaces are ready to receive cable tray and associated supports.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install cable tray in accordance with NECA 1 (general workmanship), and NEMA VE 2.
- C. Unless otherwise indicated, arrange cable tray to be parallel or perpendicular to building lines.
- D. Arrange cable tray to provide required clearances and maintain cable access.
 - 1. Minimum Clearance Above and Adjacent to Cable Tray: 12 inches.
 - 2. Cable Tray for Telecommunications Cables: Maintain recommended separation from sources of EMI greater than 5 kVA in accordance with NECA/BICSI 568.
- E. Install cable tray plumb and level, with sections aligned and with horizontal runs at the proper elevation.
- F. Metal Wire Mesh/Basket Cable Tray: Field fabricate fittings in accordance with manufacturer's instructions, using only manufacturer-approved connectors classified for bonding.
 - 1. Inside Radius of Fittings: 12 inches.
- G. Hot-Dip Galvanized After Fabrication (H.D.G.A.F.) Steel Cable Tray: After cutting, drilling, or deburring, use approved zinc-rich paint to repair finish in accordance with ASTM A780/A780M.
- H. Cable Tray Movement Provisions:
 - 1. Provide suitable expansion fittings where cable tray is subject to movement, including but not limited to:

- a. Where cable tray crosses structural joints intended for expansion.
 - b. Long straight cable tray runs in accordance with NEMA VE 2.
- 2. Use expansion guides in lieu of hold-down clamps where prescribed in NEMA VE 2.
- 3. Set gaps for expansion fittings in accordance with NEMA VE 2.
- I. Cable Provisions:
 - 1. Use suitable fixed barrier strips to maintain separation of cables as indicated and as required by NFPA 70.
 - 2. Use suitable drop-out fittings or bushings where cables exit cable tray as required to maintain minimum cable bending radius.
 - 3. Use suitable cable support fittings for long vertical cable tray runs with heavy cables.
- J. Provide end closures at unconnected ends of cable tray runs.
- K. Cable Tray Support:
 - 1. Use manufacturer's recommended hangers and supports, located in accordance with NEMA VE 2 and manufacturer's requirements, but not exceeding specified span unless otherwise approved by Engineer. Provide required support and attachment in accordance with Section 26 0529, where not furnished by cable tray manufacturer.
 - 2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- L. Grounding and Bonding Requirements, in Addition to Requirements of Section 26 0526:
 - 1. Comply with grounding and bonding requirements of NEMA VE 2.
 - 2. Metal Cable Tray Systems: Use suitable bonding jumpers or classified connectors to provide electrical continuity.
 - 3. Provide suitable equipment grounding conductor in each cable tray. Do not use metal cable tray system as equipment grounding conductor.
 - a. Equipment Grounding Conductor for Steel Cable Tray: Use bare or insulated copper conductor.
 - b. Minimum Equipment Grounding Conductor Size: 6 AWG copper.
 - c. Bond equipment grounding conductor to each cable tray section using suitable listed ground clamps. Separate bonding jumpers are not required where properly bonded equipment grounding conductor provides equivalent continuity.
- M. Conduit Termination:

1. Use listed cable tray conduit clamps (evaluated for bonding connection) to terminate conduits at cable tray.
2. Provide insulating bushing at conduit termination to protect cables.
3. Provide independent support for conduit.

N. Cable Installation:

1. Comply with cable installation requirements of NEMA VE 2.
2. Use appropriate cable pulling tools, applied to prevent excessive force on cable tray system and maintain minimum cable bending radius.
3. Use cable clamps or cable ties to fasten conductors/cables to vertical and horizontal runs of cable tray.
 - a. Distance Between Fastening Points for Vertical Runs: 18 inches.
 - b. Distance Between Fastening Points for Horizontal Runs: As required to maintain spacing and confine conductor/cable within the cable fill area.

O. Identification Requirements, in Addition to Those Specified in Section 26 0553.

1. Use warning labels to identify cable tray with the word message "WARNING! Do Not Use As A Walkway, Ladder, Or Support For Personnel. Use Only As A Mechanical Support For Cables, Tubing and Raceways." at maximum intervals of 20 feet.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect cable tray system for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective cable tray system components.

3.4 ADJUSTING

- A. Adjust tightness of mechanical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A. Remove dirt and debris from cable tray.
- B. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.6 PROTECTION

- A. Protect cable tray system from subsequent construction operations.

END OF SECTION

This page intentionally left blank

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Voltage markers.
- E. Underground warning tape.
- F. Floor marking tape.
- G. Warning signs and labels.

1.2 RELATED REQUIREMENTS

- A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.
- B. Section 26 0536 - Cable Trays for Electrical Systems: Additional identification requirements for cable tray systems.

1.3 REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.
- B. UL 969 - Marking and Labeling Systems Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.
- B. Sequencing:
 - 1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.
 - 2. Do not install identification products until final surface finishes and painting are complete.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.

1.6 FIELD CONDITIONS

- A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.
- B. No handwritten labels are permitted.

PART 2 PRODUCTS

2.1 IDENTIFICATION REQUIREMENTS

- A. Identification for Equipment:
 - 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 - a. Panelboards:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location.
 - 4) Identify main overcurrent protective device. Use identification label for panelboards with a door. For power distribution panelboards without a door, use identification nameplate.
 - 5) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces.
 - 6) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
 - 7) Identify Panel Name
 - b. Enclosed switches, circuit breakers, and motor controllers:
 - 1) Identify voltage and phase.
 - 2) Identify power source and circuit number. Include location.
 - 3) Identify load(s) served. Include location when not within sight of equipment.
 - 4) Identify enclosed breaker name
 - c. Enclosed Contactors:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.

- 3) Identify configuration, e.g., E.O.E.H. (electrically operated, electrically held) or E.O.M.H. (electrically operated, mechanically held).
 - 4) Identify coil voltage.
 - 5) Identify load(s) and associated circuits controlled. Include location.
2. Service Equipment:
- a. Use identification nameplate to identify each service disconnecting means.
 - b. For buildings or structures supplied by more than one service, or any combination of branch circuits, feeders, and services, use identification nameplate or means of identification acceptable to authority having jurisdiction at each service disconnecting means to identify all other services, feeders, and branch circuits supplying that building or structure. Verify format and descriptions with authority having jurisdiction.
 - 1) Service number one serves Magistrate.
 - 2) Service number two serves Court Services.
 - 3) Provide overall site map with service locations shown and what buildings are served from the respective services.
3. Use voltage marker to identify highest voltage present for each piece of electrical equipment.
 4. Use identification nameplate to identify equipment utilizing series ratings, where permitted, in accordance with NFPA 70.
 5. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.
 6. Use identification label on inside of door at each fused switch to identify required NEMA fuse class and size.
 7. Use identification label on inside of door at each motor controller to identify nameplate horsepower, full load amperes, code letter, service factor, voltage, and phase of motor(s) controlled.
 8. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".
 9. Use floor marking tape or warning labels to identify required equipment working clearances where indicated or where required by the authority having jurisdiction.
 10. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.

- a. Service equipment.
- 11. Arc Flash Hazard Warning Labels: Comply with Section 26 0573.
- B. Identification for Conductors and Cables:
 - 1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 0519.
 - 2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.
 - 3. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:
 - a. At each source and load connection.
 - b. Within boxes when more than one circuit is present.
 - c. Within equipment enclosures when conductors and cables enter or leave the enclosure.
 - d. In cable tray, at maximum intervals of 20 feet.
 - 4. Use wire and cable markers to identify connected grounding electrode system components for grounding electrode conductors.
 - 5. Use underground warning tape to identify direct buried cables.
- C. Identification for Raceways:
 - 1. Use voltage markers to identify highest voltage present for accessible conduits at maximum intervals of 20 feet.
 - 2. Use voltage markers or color-coded bands to identify systems other than normal power system for accessible conduits at maximum intervals of 20 feet.
 - a. Color-Coded Bands: Use vinyl color coding electrical tape to mark bands 3 inches wide.
 - 1) Color Code:
 - (a) Fire Alarm System: Red.
 - 2) Vinyl Color Coding Electrical Tape: Comply with Section 26 0519.
 - 3. Use identification labels or plastic marker tags to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.

4. Use identification labels or plastic marker tags to identify spare conduits at each end. Identify purpose and termination location.
 5. Use underground warning tape to identify underground raceways.
 6. Use voltage markers to identify highest voltage present for wireways at maximum intervals of 20 feet.
- D. Identification for Cable Tray: Comply with Section 26 0536.
- E. Identification for Boxes:
1. Use voltage markers to identify highest voltage present.
 2. Use voltage markers or color coded boxes to identify systems other than normal power system.
 - a. Fire Alarm System: Red.
 3. For exposed boxes in public areas, do not color code.
 4. Use identification labels to identify circuits enclosed.
 - a. For exposed boxes in public areas, use only identification labels.
- F. Identification for Devices:
1. Wiring Device and Wallplate Finishes: Comply with Section 26 2726.
 2. Use identification label to identify fire alarm system devices.
 - a. For devices concealed above suspended ceilings, provide additional identification on ceiling tile below device location.
 3. Use identification label or engraved wallplate to identify serving branch circuit for all receptacles.
 - a. For receptacles in all areas, provide identification on inside surface of wallplate.
 4. Use identification label or engraved wallplate to identify load controlled for wall-mounted control devices controlling loads that are not visible from the control location and for multiple wall-mounted control devices installed at one location.
 5. Use identification label to identify receptacles protected by upstream GFI protection, where permitted.
- G. Identification for Luminaires:
1. Use permanent red dot on luminaire frame to identify luminaires with integral emergency power system (batteries).

2.2 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:

1. Materials:
 - a. Indoor Clean, Dry Locations: Use plastic nameplates.
 - b. Outdoor Locations: Use plastic, stainless steel, or aluminum nameplates suitable for exterior use.
2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
 - a. Exception: Provide minimum thickness of 1/8 inch when any dimension is greater than 4 inches.
3. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved or laser-etched text.
4. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text.
5. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.

B. Identification Labels:

1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
 - a. Use only for indoor locations.
2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

C. Format for Equipment Identification:

1. Minimum Size: 1 inch by 2.5 inches.
2. Legend:
 - a. System designation where applicable:
 - 1) Fire Alarm System: Identify with text "FIRE ALARM".
 - b. Equipment designation or other approved description.
 - c. Other information as indicated.
3. Text: All capitalized unless otherwise indicated.
4. Minimum Text Height:

- a. System Designation: 1 inch.
 - b. Equipment Designation: 1/2 inch.
 - c. Other Information: 1/4 inch.
 - d. Exception: Provide minimum text height of 1 inch for equipment located more than 10 feet above floor or working platform.
- 5. Color:
 - a. Normal Power System: White text on black background.
 - b. Fire Alarm System: White text on red background.
- D. Format for General Information and Operating Instructions:
 - 1. Minimum Size: 1 inch by 2.5 inches.
 - 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height: 1/4 inch.
 - 5. Color: Black text on white background unless otherwise indicated.
 - a. Exceptions:
 - 1) Provide white text on red background for general information or operational instructions for fire alarm systems.
- E. Format for Caution and Warning Messages:
 - 1. Minimum Size: 2 inches by 4 inches.
 - 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height: 1/2 inch.
 - 5. Color: Black text on yellow background unless otherwise indicated.
- F. Format for Receptacle Identification:
 - 1. Minimum Size: 3/8 inch by 1.5 inches.
 - 2. Legend: Power source and circuit number or other designation indicated.
 - a. Include voltage and phase for other than 120 V, single phase circuits.

3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height: 3/16 inch.
 5. Color: Black text on clear background.
- G. Format for Control Device Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
 2. Legend: Load controlled or other designation indicated.
 3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height: 3/16 inch.
 5. Color: Black text on clear background.
- H. Format for Fire Alarm Device Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
 2. Legend: Designation indicated and device zone or address.
 3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height: 3/16 inch.
 5. Color: Red text on white background.

2.3 WIRE AND CABLE MARKERS

- A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- B. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- C. Legend: Power source and circuit number or other designation indicated.
- D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
1. Do not use handwritten text.
- E. Minimum Text Height: 1/8 inch.
- F. Color: Black text on white background unless otherwise indicated.

2.4 VOLTAGE MARKERS

- A. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.
- B. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.
- C. Minimum Size:
 - 1. Markers for Equipment: 1 1/8 by 4 1/2 inches.
 - 2. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.
 - 3. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
 - 4. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- D. Legend:
 - 1. Markers for Voltage Identification: Highest voltage present.
- E. Color: Black text on orange background unless otherwise indicated.

2.5 UNDERGROUND WARNING TAPE

- A. Materials: Use foil-backed detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
- B. Foil-backed Detectable Type Tape: 3 inches wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.
- C. Legend: Type of service, continuously repeated over full length of tape.
- D. Color:
 - 1. Tape for Buried Power Lines: Black text on red background.
 - 2. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

2.6 FLOOR MARKING TAPE

- A. Floor Marking Tape for Equipment Working Clearance Identification: Self-adhesive vinyl or polyester tape with overlamine, 3 inches wide, with alternating black and white stripes.

2.7 WARNING SIGNS AND LABELS

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
 - 1. Materials:

- a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.
 - b. Outdoor Locations: Use factory pre-printed rigid aluminum signs.
- 2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
- 3. Minimum Size: 7 by 10 inches unless otherwise indicated.
- C. Warning Labels:
 - 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
 - a. Do not use labels designed to be completed using handwritten text.
 - 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
 - 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
 - 1. Surface-Mounted Equipment: Enclosure front.
 - 2. Flush-Mounted Equipment: Inside of equipment door.
 - 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 - 4. Elevated Equipment: Legible from the floor or working platform.
 - 5. Branch Devices: Adjacent to device.
 - 6. Interior Components: Legible from the point of access.
 - 7. Conduits: Legible from the floor.
 - 8. Boxes: Outside face of cover.

- 9. Conductors and Cables: Legible from the point of access.
- 10. Devices: Outside face of cover.
- C. Install identification products centered, level, and parallel with lines of item being identified.
- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.
 - 1. Do not use adhesives on exterior surfaces except where substrate cannot be penetrated.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.
- F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.
- G. Secure rigid signs using stainless steel screws.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

This page intentionally left blank

SECTION 26 0583 - WIRING CONNECTIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Electrical connections to equipment.

1.2 RELATED REQUIREMENTS

- A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.
- B. Section 26 0533.13 - Conduit for Electrical Systems.
- C. Section 26 0533.16 - Boxes for Electrical Systems.
- D. Section 26 2726 - Wiring Devices.
- E. Section 26 2816.16 - Enclosed Switches.

1.3 REFERENCE STANDARDS

- A. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2021.
- B. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
 - 2. Determine connection locations and requirements.
- B. Sequencing:
 - 1. Install rough-in of electrical connections before installation of equipment is required.
 - 2. Make electrical connections before required start-up of equipment.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
 - 1. Colors: Conform to NEMA WD 1.
 - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
 - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
- B. Disconnect Switches: As specified in Section 26 2816.16 and in individual equipment sections.
- C. Wiring Devices: As specified in Section 26 2726.
- D. Flexible Conduit: As specified in Section 26 0533.13.
- E. Wire and Cable: As specified in Section 26 0519.
- F. Boxes: As specified in Section 26 0533.16.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

END OF SECTION

This page intentionally left blank

SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Occupancy sensors.
- B. Accessories.

1.2 RELATED REQUIREMENTS

- A. Section 26 0529 - Hangers and Supports for Electrical Systems
- B. Section 26 0533.16 - Boxes for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 2726 - Wiring Devices: Devices for manual control of lighting, including wall switches, wall dimmers, and fan speed controllers.
- E. Section 26 5100 - Interior Lighting.
- F. Section 26 5600 - Exterior Lighting.

1.3 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- C. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices 2017.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.
- E. UL 773A - Nonindustrial Photoelectric Switches for Lighting Control Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of lighting control devices with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate the placement of wall switch occupancy sensors with actual installed door swings.
 - 3. Coordinate the placement of occupancy sensors with millwork, furniture, equipment or other potential obstructions to motion detection coverage installed under other sections or by others.

4. Notify Architect/Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.
- B. Sequencing:
1. Do not install lighting control devices until final surface finishes and painting are complete.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
1. Occupancy Sensors: Include detailed motion detection coverage range diagrams.
- C. Shop Drawings:
1. Occupancy Sensors: Provide lighting plan indicating location, model number, and orientation of each occupancy sensor and associated system component.
- D. Operation and Maintenance Data: Include detailed information on device programming and setup.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 6000 - Product Requirements, for additional provisions.
- F. Project Record Documents: Record actual installed locations and settings for lighting control devices.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.8 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for all occupancy sensors.

PART 2 PRODUCTS

2.1 LIGHTING CONTROL DEVICES - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.

2.2 OCCUPANCY SENSORS

- A. All Occupancy Sensors:
 - 1. Description: Factory-assembled commercial specification grade devices for indoor use capable of sensing both major motion, such as walking, and minor motion, such as small desktop level movements, according to published coverage areas, for automatic control of load indicated.
 - 2. Sensor Technology:
 - a. Passive Infrared/Ultrasonic Dual Technology Occupancy Sensors: Designed to detect occupancy using a combination of both passive infrared and ultrasonic technologies.
 - 3. Provide LED to visually indicate motion detection with separate color LEDs for each sensor type in dual technology units.
 - 4. Occupancy Operation: Unless otherwise indicated, occupancy sensor to turn load on when occupant presence is detected and to turn load off when no occupant presence is detected during an adjustable turn-off delay time interval.
 - 5. Vancancy operation unless otherwise indicated, vancancy sensor requires lights to be turned on manually and the sensor will turn loads off when no occpant presence is detected during an adjustable turn-off delay time interval.
 - 6. Dual Technology Occupancy Sensors: Field configurable turn-on and hold-on activation with settings for activation by either or both sensing technologies.
 - 7. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.
 - 8. Sensitivity: Field adjustable.
 - 9. Adaptive Technology: Field selectable; capable of self-adjusting sensitivity and time delay according to conditions.
 - 10. Load Rating for Line Voltage Occupancy Sensors: As required to control the load indicated on drawings.
- B. Wall Switch Occupancy Sensors:

1. All Wall Switch Occupancy Sensors:
 - a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated manual control capability, and no leakage current to load in off mode.
 - b. Operation: Field selectable to operate either as occupancy sensor (automatic on/off) or as vacancy sensor (manual-on/automatic off).
 - c. Manual-Off Override Control: When used to turn off load while in automatic-on mode, unit to revert back to automatic mode after no occupant presence is detected during the delayed-off time interval.
 - d. Finish: Match finishes specified for wiring devices in Section 26 2726, unless otherwise indicated.
- C. Ceiling Mounted Occupancy Sensors:
 1. All Ceiling Mounted Occupancy Sensors:
 - a. Description: Low profile occupancy sensors designed for ceiling installation.
 - b. Provide field selectable setting for disabling LED motion detector visual indicator.
 - c. Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
 - d. Finish: White unless otherwise indicated.
 2. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within an area of 450 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
- D. Directional Occupancy Sensors:
 1. All Directional Occupancy Sensors: Designed for wall or ceiling mounting, with integral swivel for field adjustment of motion detection coverage.
 - a. Provide field selectable setting for disabling LED motion detector visual indicator.
 - b. Finish: White unless otherwise indicated.
 2. Passive Infrared/Ultrasonic Dual Technology Directional Occupancy Sensors: Capable of detecting motion within a distance of 40 feet at a mounting height of 10 feet.
- E. Power Packs for Low Voltage Occupancy Sensors:
 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage occupancy sensors for switching of line voltage loads.

2. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
3. Input Supply Voltage: Dual rated for 120/277 V ac.
4. Load Rating: As required to control the load indicated on drawings.

2.3 ACCESSORIES

A. Auxiliary Contacts:

1. Comply with NEMA ICS 5.
2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each lighting contactor, minimum.

B. Pilot Devices:

1. Comply with NEMA ICS 5; heavy-duty type.
2. Nominal Size: 30 mm.
3. Pushbuttons: Unless otherwise indicated, provide momentary, non-illuminated type with flush button operator; normally open or normally closed as indicated or as required.
4. Selector Switches: Unless otherwise indicated, provide maintained, non-illuminated type with knob operator; number of switch positions as indicated or as required.
5. Indicating Lights: Push-to-test type unless otherwise indicated.
6. Provide LED lamp source for indicating lights and illuminated devices.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.

- G. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130.
- B. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of lighting control devices provided under this section.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. Install lighting control devices plumb and level, and held securely in place.
- F. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 26 2726.
- G. Provide required supports in accordance with Section 26 0529.
- H. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- I. Identify lighting control devices in accordance with Section 26 0553.
- J. Occupancy Sensor Locations:
 - 1. Location Adjustments: Locations indicated are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for complete coverage of respective room or area based on manufacturer's recommendations for installed devices.
 - 2. Locate dual technology passive infrared/ultrasonic occupancy sensors a minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
- K. Lamp Burn-In: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.
- L. Unless otherwise indicated, install power packs for lighting control devices above accessible ceiling or above access panel in inaccessible ceiling near the sensor location.

- M. Where indicated, install separate compatible wall switches for manual control interface with lighting control devices or associated power packs.
- N. Unless otherwise indicated, install switches on load side of power packs so that switch does not turn off power pack.
- O. Where indicated or required, provide cabinet or enclosure in accordance with Section 26 0533.16 for mounting of lighting control device system components.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect each lighting control device for damage and defects.
- C. Test occupancy sensors to verify proper operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
- D. Correct wiring deficiencies and replace damaged or defective lighting control devices.

3.5 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust occupancy sensor settings to minimize undesired activations while optimizing energy savings, and to achieve desired function as indicated or as directed by Architect/Engineer. Adjust sensors to not pickup movement outside of the doorway.
- C. Adjust position of directional occupancy sensors and outdoor motion sensors to achieve optimal coverage as required.
- D. Where indicated or as directed by Architect, install factory masking material or adjust integral blinders on dual technology occupancy sensor lenses to block undesired motion detection.

3.6 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.7 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of lighting control devices to Architect/Engineer, and correct deficiencies or make adjustments as directed.
- C. Training: Train Owner's personnel on operation, adjustment, programming, and maintenance of lighting control devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.

2. Provide minimum of two hours of training.
3. Instructor: Manufacturer's authorized service representative.
4. Location: At project site.

END OF SECTION

SECTION 26 2416 - PANELBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Lighting and appliance panelboards.
- B. Overcurrent protective devices for panelboards.

1.2 RELATED REQUIREMENTS

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.3 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e, with Amendment (2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA PB 1 - Panelboards 2011.
- F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less 2013.
- G. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- H. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- K. UL 67 - Panelboards Current Edition, Including All Revisions.
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- M. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.

- N. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- O. UL 1053 - Ground-Fault Sensing and Relaying Equipment Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
 - 1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of panelboards and adjacent equipment with all required clearances indicated.
 - 2. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
- D. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- E. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 6000 - Product Requirements, for additional provisions.
2. Panelboard Keys: Two of each different key.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

- A. Maintain ambient temperature within the following limits during and after installation of panelboards:
 1. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 1. Altitude: Less than 6,600 feet.
 2. Ambient Temperature:
 - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.

- C. Short Circuit Current Rating:
 - 1. Provide panelboards with listed short circuit current rating as indicated on the drawings.
- D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
 - 1. Provide fully rated neutral bus, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
 - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
 - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
 - c. Provide removable end walls for NEMA Type 1 enclosures.
 - 3. Fronts:
 - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
 - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
 - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
 - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

- J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 4300, list and label panelboards as a complete assembly including surge protective device.
- K. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
 - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
 - 2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
 - a. Use zero sequence ground fault detection method unless otherwise indicated.
 - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
- L. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.
- M. Load centers are not acceptable.
- N. Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Feed-through lugs.
 - 2. Sub-feed lugs.

2.3 LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
 - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
 - 2. Phase and Neutral Bus Material: Aluminum.
 - 3. Ground Bus Material: Aluminum.
- D. Circuit Breakers: Thermal magnetic bolt-on type.

E. Enclosures:

1. Provide surface-mounted or flush-mounted enclosures as indicated.
2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
3. Provide clear plastic circuit directory holder mounted on inside of door.

2.4 OVERCURRENT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers:

1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489 and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
2. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
3. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
 - b. Provide interchangeable trip units for circuit breaker frame sizes 225 amperes and larger.
5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - a. Provide the following field-adjustable trip response settings:
 - 1) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.

- 2) Long time delay.
 - 3) Short time pickup and delay.
 - 4) Instantaneous pickup.
 - 5) Ground fault pickup and delay where ground fault protection is indicated.
- 6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
 - 7. Provide the following circuit breaker types where indicated:
 - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
 - b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
 - 8. Do not use tandem circuit breakers.
 - 9. Do not use handle ties in lieu of multi-pole circuit breakers.
 - 10. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
 - 11. Provide the following features and accessories where indicated or where required to complete installation:
 - a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
 - b. Handle Pad-Lock Provision: For locking circuit breaker handle in OFF position.

2.5 SOURCE QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Factory test panelboards according to NEMA PB 1.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 26 0529.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I. Provide grounding and bonding in accordance with Section 26 0526.
- J. Install all field-installed branch devices, components, and accessories.
- K. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- L. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.
- M. Provide filler plates to cover unused spaces in panelboards.
- N. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
 - 1. Emergency and night lighting circuits.
 - 2. Fire detection and alarm circuits.
 - 3. Communications equipment circuits.
 - 4. Intrusion detection and access control system circuits.
 - 5. Video surveillance system circuits.
- O. Identify panelboards in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.

- C. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than 225 amperes. Tests listed as optional are not required.
- D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
 - 1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.
- E. Test GFCI circuit breakers to verify proper operation.
- F. Test shunt trips to verify proper operation.
- G. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.5 CLEANING

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

This page intentionally left blank

SECTION 26 2726 - WIRING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Wall switches.
- B. Wall dimmers.
- C. Receptacles.
- D. Wall plates.
- E. Floor box service fittings.

1.2 RELATED REQUIREMENTS

- A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables: Manufactured wiring systems for use with access floor boxes with compatible pre-wired connectors.
- B. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- C. Section 26 0533.16 - Boxes for Electrical Systems.
- D. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.3 REFERENCE STANDARDS

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for 2014h, with Amendments (2017).
- B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification) 2014g, with Amendment (2017).
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- E. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2020).
- F. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2021.
- G. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- H. UL 20 - General-Use Snap Switches Current Edition, Including All Revisions.
- I. UL 498 - Attachment Plugs and Receptacles Current Edition, Including All Revisions.
- J. UL 514D - Cover Plates for Flush-Mounted Wiring Devices Current Edition, Including All Revisions.

- K. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- L. UL 1449 - Standard for Surge Protective Devices Current Edition, Including All Revisions.
- M. UL 1472 - Solid-State Dimming Controls Current Edition, Including All Revisions.
- N. UL 1917 - Solid-State Fan Speed Controls Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
5. Notify Architect/Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

B. Sequencing:

1. Do not install wiring devices until final surface finishes and painting are complete.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
- C. Operation and Maintenance Data:
 1. Wall Dimmers: Include information on operation and setting of presets.
 2. GFCI Receptacles: Include information on status indicators.
- D. Project Record Documents: Record actual installed locations of wiring devices.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 6000 - Product Requirements, for additional provisions.
 2. Extra Wall Plates: One of each style, size, and finish.
 3. Extra Flush Floor Service Fittings: Two of each type.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.1 WIRING DEVICE APPLICATIONS

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles installed in kitchens.
- F. Provide GFCI protection for receptacles serving electric drinking fountains.
- G. Unless noted otherwise, do not use combination switch/receptacle devices.
- H. For flush floor service fittings, use tile rings for installations in tile floors.
- I. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

2.2 WIRING DEVICE FINISHES

- A. Provide wiring device finishes as selected by architect unless otherwise indicated.

2.3 WALL SWITCHES

- A. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable FS W-S-896; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.
- B. Standard Wall Switches: Commercial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole

single throw, three way, or four way as indicated on the drawings.

2.4 WALL DIMMERS

- A. Wall Dimmers - General Requirements: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1472; types and ratings suitable for load controlled as indicated on the drawings.
- B. Control: Slide control type with separate on/off switch.
- C. Power Rating, Unless Otherwise Indicated or Required to Control the Load Indicated on the Drawings:

2.5 FAN SPEED CONTROLLERS

- A. Description: 120 V AC, solid-state, full-range variable speed, slide control type with separate on/off switch, with integral radio frequency interference filtering, fan noise elimination circuitry, power failure preset memory, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1917.
 - 1. Current Rating: 1.5 A unless otherwise indicated or required to control the load indicated on the drawings.

2.6 RECEPTACLES

- A. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring with separate ground terminal screw.
 - 2. NEMA configurations specified are according to NEMA WD 6.
- B. Convenience Receptacles:
 - 1. Standard Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
 - 2. Weather Resistant Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
- C. GFCI Receptacles:
 - 1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
 - a. Provide test and reset buttons of same color as device.

2. Standard GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
3. Weather Resistant GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.

2.7 WALL PLATES

- A. Wall Plates: Comply with UL 514D.
 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
 2. Size: Standard.
 3. Screws: Metal with slotted heads finished to match wall plate finish.
- B. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.
- C. Weatherproof Covers for Damp Locations: Gasketed, cast aluminum, with self-closing hinged cover and corrosion-resistant screws; listed as suitable for use in wet locations with cover closed.
- D. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

2.8 FLOOR BOX SERVICE FITTINGS

- A. Description: Service fittings compatible with floor boxes provided under Section 26 0533.16 with components, adapters, and trims required for complete installation.
- B. Flush Floor Service Fittings:
 1. Dual Service Flush Combination Outlets:
 - a. Cover: Rectangular.
 - b. Configuration:
 - 1) Power: One standard convenience duplex receptacle(s) with duplex flap opening(s).
 - 2) Voice and Data Jacks: Provided by others.
 2. Accessories:
 - a. Tile Rings: Finish to match covers; configuration as required to accommodate specified covers.

- b. Carpet Flanges: Finish to match covers; configuration as required to accommodate specified covers.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that floor boxes are adjusted properly and location confirmed by Owner/Architect.
- F. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- G. Verify that core drilled holes for poke-through assemblies are in proper locations and location confirmed Owner/Architect.
- H. Verify that openings in access floor are in proper locations and location confirmed by owner/architect.
- I. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of wiring devices provided under this section.
 - 1. Mounting Heights: Unless otherwise indicated, as follows:
 - a. Wall Switches: 48 inches above finished floor.
 - b. Wall Dimmers: 48 inches above finished floor.
 - c. Receptacles: 18 inches above finished floor or 6 inches above counter.
 - 2. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.

3. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
 4. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect/Engineer to obtain direction prior to proceeding with work.
 5. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
- C. Install wiring devices in accordance with manufacturer's instructions.
 - D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
 - E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
 - F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
 - G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
 - H. Unless otherwise indicated, GFCI receptacles may be connected to provide feed-through protection to downstream devices. Label such devices to indicate they are protected by upstream GFCI protection.
 - I. Install wiring devices plumb and level with mounting yoke held rigidly in place.
 - J. Install wall switches with OFF position down.
 - K. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
 - L. Do not share neutral conductor on branch circuits utilizing wall dimmers.
 - M. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
 - N. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
 - O. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
 - P. Identify wiring devices in accordance with Section 26 0553.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- D. Test each receptacle to verify operation and proper polarity.
- E. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- F. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.5 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust presets for wall dimmers according to manufacturer's instructions as directed by Architect/Engineer.

3.6 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

SECTION 26 2813 - FUSES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fuses.

1.2 RELATED REQUIREMENTS

- A. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- B. Section 26 2816.16 - Enclosed Switches: Fusible switches.

1.3 REFERENCE STANDARDS

- A. NEMA FU 1 - Low Voltage Cartridge Fuses 2012.
- B. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- C. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements Current Edition, Including All Revisions.
- D. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses Current Edition, Including All Revisions.
- E. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
 - a. Fusible Enclosed Switches: See Section 26 2816.16.
 - 2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
 - 3. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.

2. Extra Fuses: One set(s) of three for each type and size installed.
3. Fuse Pullers: One set(s) compatible with each type and size installed.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 APPLICATIONS

- A. General Purpose Branch Circuits: Class RK1, time-delay.
- B. Individual Motor Branch Circuits: Class RK5, time-delay.
- C. In-Line Protection for Pole-Mounted Luminaires: Class CC, time-delay.
- D. Primary Protection for Control Transformers: Class CC, time-delay.

2.2 FUSES

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C. Provide fuses of the same type, rating, and manufacturer within the same switch.
- D. Comply with UL 248-1.
- E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
- F. Voltage Rating: Suitable for circuit voltage.
- G. Class R Fuses: Comply with UL 248-12.
 1. Class RK1, Time-Delay Fuses: Minimum 200KAIC.
 2. Class RK5, Time-Delay Fuses: Minimum 200KAIC.
- H. Class CC Fuses: Comply with UL 248-4.
- I. Provide the following accessories where indicated or where required to complete installation:
 1. Fuseholders: Compatible with indicated fuses.

2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.
- B. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Do not install fuses until circuits are ready to be energized.
- B. Install fuses with label oriented such that manufacturer, type, and size are easily read.
- C. Provide label inside enclosure with fuse manufacturer, type and size.

END OF SECTION

This page intentionally left blank

SECTION 26 2816.13 - ENCLOSED CIRCUIT BREAKERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Enclosed circuit breakers.

1.2 RELATED REQUIREMENTS

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.3 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e, with Amendment (2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- E. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- H. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted enclosed circuit breakers where indicated.

4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 1. Include dimensioned plan and elevation views of enclosed circuit breakers and adjacent equipment with all required clearances indicated.
 2. Include wiring diagrams showing all factory and field connections.
 3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed circuit breaker internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

- A. Maintain ambient temperature between 23 degrees F and 104 degrees F during and after installation of enclosed circuit breakers.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Furnish enclosed circuit breakers and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and

obtained from a single supplier.

2.2 ENCLOSED CIRCUIT BREAKERS

- A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between 23 degrees F and 104 degrees F.
- D. Short Circuit Current Rating:
- E. Conductor Terminations: Suitable for use with the conductors to be installed.
- F. Provide thermal magnetic circuit breakers for circuit breaker frame sizes less than 225 amperes.
- G. Provide insulated, groundable fully rated solid neutral assembly, with a suitable lug for terminating each neutral conductor.
- H. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.
- I. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
 - 3. Provide surface-mounted enclosures unless otherwise indicated.
- J. Provide externally operable handle with means for locking in the OFF position.

2.3 MOLDED CASE CIRCUIT BREAKERS

- A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489 and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
- B. Interrupting Capacity:

1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - a. 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
- C. Conductor Terminations:
1. Provide mechanical lugs unless otherwise indicated.
 2. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
- D. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
1. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
- E. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings of the enclosed circuit breakers are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed circuit breakers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 0529.
- E. Install enclosed circuit breakers plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed circuit breakers such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

- G. Provide grounding and bonding in accordance with Section 26 0526.
- H. Identify enclosed circuit breakers in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with manufacturer's instructions and NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for circuit breakers used for service entrance and for circuit breakers larger than 225 amperes. Tests listed as optional are not required.
- D. Correct deficiencies and replace damaged or defective enclosed circuit breakers.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A. Clean dirt and debris from circuit breaker enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

This page intentionally left blank

SECTION 26 2816.16 - ENCLOSED SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Enclosed safety switches.

1.2 RELATED REQUIREMENTS

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 2813 - Fuses.
- E. Section 26 3600 - Transfer Switches: Automatic and non-automatic switches listed for use as transfer switch equipment.

1.3 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum) 2013.
- D. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- E. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- H. UL 98 - Enclosed and Dead-Front Switches Current Edition, Including All Revisions.
- I. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.

2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
4. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 1. Include dimensioned plan and elevation views of enclosed switches and adjacent equipment with all required clearances indicated.
- D. Project Record Documents: Record actual locations of enclosed switches.
- E. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 6000 - Product Requirements, for additional provisions.
 2. See Section 26 2813 for requirements for spare fuses.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

1.8 FIELD CONDITIONS

- A. Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.2 ENCLOSED SAFETY SWITCHES

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D. Horsepower Rating: Suitable for connected load.
- E. Voltage Rating: Suitable for circuit voltage.
- F. Short Circuit Current Rating:
 - 1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
 - 2. Minimum Ratings:
 - a. Heavy Duty Single Throw Switches Protected by Class R Fuses: 200,000 rms symmetrical amperes.
- G. Enclosed Safety Switches Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- H. Provide with switch blade contact position that is visible when the cover is open.
- I. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
 - 1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.
- J. Conductor Terminations: Suitable for use with the conductors to be installed.

- K. Provide insulated, groundable fully rated solid neutral assembly, with a suitable lug for terminating each neutral conductor.
- L. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- M. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- N. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- O. Heavy Duty Switches:
 - 1. Comply with NEMA KS 1.
 - 2. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.
- P. Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Hubs: As required for environment type; sized to accept conduits to be installed.
 - 2. Integral fuse pullers.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed safety switches.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 0529.
- E. Install enclosed switches plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 0526.
- H. Provide fuses complying with Section 26 2813 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- J. Identify enclosed switches in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- D. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.4 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

- A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

This page intentionally left blank

SECTION 26 3213 - ENGINE GENERATORS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Packaged engine generator system and associated components and accessories:
 - 1. Engine and engine accessory equipment.
 - 2. Alternator (generator).
 - 3. Generator set control system.
 - 4. Generator set enclosure.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- C. Section 26 0529 - Hangers and Supports for Electrical Systems.
- D. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 26 3600 - Transfer Switches.

1.3 REFERENCE STANDARDS

- A. ASTM D975 - Standard Specification for Diesel Fuel 2023.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA/EGSA 404 - Standard for Installing Generator Sets 2014.
- D. NEMA MG 1 - Motors and Generators 2021.
- E. NFPA 30 - Flammable and Combustible Liquids Code 2024.
- F. NFPA 37 - Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines 2021.
- G. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- H. NFPA 110 - Standard for Emergency and Standby Power Systems 2022.
- I. UL 142 - Steel Aboveground Tanks for Flammable and Combustible Liquids Current Edition, Including All Revisions.
- J. UL 1236 - Battery Chargers for Charging Engine-Starter Batteries Current Edition, Including All Revisions.

K. UL 2200 - Stationary Engine Generator Assemblies Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate compatibility of generator sets to be installed with work provided under other sections or by others.
 - a. Transfer Switches: See Section 26 3600.
2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment or other potential obstructions within the spaces dedicated for engine generator system.
3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
4. Coordinate the work to provide electrical circuits suitable for the power requirements of the actual auxiliary equipment and accessories to be installed.
5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features. Include alternator starting capabilities, engine fuel consumption rates, and cooling, combustion air, and exhaust requirements.
- B. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, work platform and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.
- C. Derating Calculations: Indicate ratings adjusted for applicable service conditions.
- D. Manufacturer's factory emissions certification.
- E. Provide NFPA 110 required documentation from manufacturer, including but not limited to:
 1. Certified prototype tests.
 2. Torsional vibration compatibility certification.
 3. NFPA 110 compliance certification.
 4. Certified rated load test at rated power factor.
- F. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- G. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. Extra Fuses: One of each type and size.
 2. Extra Filter Elements: One of each type, including fuel, oil and air.

1.6 QUALITY ASSURANCE

- A. Comply with the following:
 1. NFPA 70 (National Electrical Code); 2017.
 2. NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for Optional Standby system (NEC 702).
 3. NFPA 37 (Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines).
 4. NFPA 30 (Flammable and Combustible Liquids Code).
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store generator sets in accordance with manufacturer's instructions and NECA/EGSA 404.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to generator set components, enclosure, and finish.

1.8 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Furnish engine generator sets and associated components and accessories produced by a single manufacturer and obtained from a single supplier.

2.2 PACKAGED ENGINE GENERATOR SYSTEM

- A. Provide new engine generator system consisting of all required equipment, sensors, conduit, boxes, wiring, piping, supports, accessories, system programming, work platform, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. System Description:
 - 1. Application: Emergency/standby.
 - 2. Configuration: Single packaged engine generator set operated independently (not in parallel).
 - 3. Where design is based on single generator set, use of multiple, smaller unit(s) operated in parallel to obtain equivalent total system power rating is not permitted.
- D. Generator Set General Requirements:
 - 1. Prototype tested in accordance with NFPA 110 for Optional Standby systems.
 - 2. Factory-assembled, with components mounted on suitable base.
 - 3. List and label engine generator assembly as complying with UL 2200 testing.
 - 4. Power Factor: Unless otherwise indicated, specified power ratings are at 0.8 power factor for three phase voltages and 1.0 power factor for single phase voltages.
 - 5. Provide suitable guards to protect personnel from accidental contact with rotating parts, hot piping, and other potential sources of injury.
 - 6. Main Line Circuit Breakers: Provide factory-installed line side connections with suitable lugs for load side connections.
- E. Service Conditions: Provide engine generator system and associated components suitable for operation under the service conditions at the installed location.
- F. Starting and Load Acceptance Requirements:
 - 1. Cranking Method: Cycle cranking (15 second crank period, followed by 15 second rest period, with cranking limiter time-out after 3 cycles), unless otherwise required.
 - 2. Cranking Limiter Time-Out: If generator set fails to start after specified cranking period, indicate overcrank alarm condition and lock-out generator set from further cranking until

manually reset.

3. Start Time: Capable of starting and achieving conditions necessary for load acceptance within 10 seconds (Type 10, Class 24).
 4. Maximum Load Step: Supports 100 percent of rated load in one step.
 - a. Maximum Voltage Deviation with Load Step: 15 percent.
 - b. Maximum Frequency Deviation with Load Step: 15 percent.
- G. Exhaust Emissions Requirements:
1. Comply with federal (EPA), state, and local regulations applicable at the time of commissioning; include factory emissions certification with submittals.
 2. Do not make modifications affecting generator set factory emissions certification without approval of manufacturer and Engineer. Where such modifications are made, provide field emissions testing as necessary for certification.
- H. Sound Level Requirements:
1. Do not exceed 75 dBA when measured at 23 feet from generator set in free field (no sound barriers) while operating at full load; include manufacturer's sound data with submittals.
 2. Comply with applicable noise level regulations.

2.3 ENGINE AND ENGINE ACCESSORY EQUIPMENT

- A. Provide engine with adequate horsepower to achieve specified power output at rated speed, accounting for alternator efficiency and parasitic loads.
- B. Engine Fuel System - Diesel (Compression Ignition):
1. Fuel Source: Diesel, ASTM D975 No. 2-D or approved cold weather diesel blends.
 2. Fuel Storage: Sub-base fuel tank.
 3. Engine Fuel Supply: Provide engine-driven, positive displacement fuel pump with replaceable fuel filter(s), water separator, check valve to secure prime, manual fuel priming pump, and relief-bypass valve. Provide fuel cooler where recommended by manufacturer.
 4. Engine Fuel Connections: Provide suitable, approved flexible fuel lines for coupling engine to fuel source.
 5. Sub-Base Fuel Tank:
 - a. Provide sub-base mounted, double-wall fuel tank with secondary containment; listed and labeled as complying with UL 142.

- b. Tank Capacity: Size for minimum of 24 hours of continuous engine generator operation at 100 percent rated load, but not larger than permissible by applicable codes.
- c. Features:
 - 1) Direct reading fuel level gauge.
 - 2) Normal atmospheric vent.
 - 3) Emergency pressure relief vent.
 - 4) Fuel fill opening with lockable cap.
 - 5) Dedicated electrical conduit stub-up area.
 - 6) Low fuel level switch.
 - 7) Leak detection switch; located within secondary containment interstitial space for detection of primary tank fuel leak.
- C. Where required for "readily accessible" NEC requirements, provide aluminum or fiberglass access work platform(s) with ladder and handrails.
- D. Generator Work Platform:
 - 1. Generator manufacturer shall provide work platform configured for generator provided with requirements stated herein and on plans.
 - 2. Minimum of 36" platform from generator enclosure to handrail.
 - 3. Live Loads: 40PSF or 300lbs concentrated.
 - 4. Ground Snow Loads: 30 PSF, risk category II, importance factor 1.0
 - 5. Wind Loads:
 - a. Basic Design Wind Speed: 108 MPH.
 - b. Allowable Design Wind Speed: 84 MPH
 - c. Exposure Category B.
 - d. Risk Category II.
 - 6. Structural Steel shall conform to ASTM A36 for channels, angles and plates and ASTM A35, grade B for pipes.
 - 7. All bolts shall conform to ASTM A307.
 - 8. Welds shall be made with E-70 electrodes and be in accordance with AWS D1.1/D1.1M.

9. All detailing, fabrication and erection of structural steel shall conform to the requirements of the AISC specifications for buildings, ASD design, 14th Edition.
10. Where the work of other trades requires cuts, holes, etc., in structural steel members, cuts, holes, etc., shall be made in the shop and shall be shown on the shop drawings. Making holes or cuts in the field will not be permitted.
11. All structural steel sections shall be hot-dip galvanized in accordance with ASTM A123. Provide a coating with a minimum thickness of 1.7 oz/sq ft. Fasteners shall be galvanized in accordance with ASTM A153 Class C.
12. Grating shall be 1 1/4x 3/16, 19-W-4 bar grating. Bar grating shall be hot-dip galvanized in accordance with ASTM A123. Provide a coating with a minimum thickness of 1.7 oz/sq ft.
13. Guardrail system shall use galvanized post/rail fitting connection. Minimum height shall be 36" above platform with interm height guardrail.
14. Access ladder shall have minimum of #6 galvanized rebar for rungs spaced 10" min to 14" max and a width of 1'-4" wide.

E. Engine Starting System:

1. System Type: Electric, with DC solenoid-activated starting motor(s).
2. Battery(s):
 - a. Battery Type: Lead-acid.
 - b. Battery Capacity: Size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature; capable of providing cranking through two complete periods of cranking limiter time-outs without recharging.
 - c. Provide battery rack, cables, and connectors suitable for the supplied battery(s); size battery cables according to manufacturer's recommendations for cable length to be installed.
3. Battery-Charging Alternator: Engine-driven, with integral solid-state voltage regulation.
4. Battery Charger:
 - a. Provide dual rate battery charger with automatic float and equalize charging modes and minimum rating of 10 amps; suitable for maintaining the supplied battery(s) at full charge without manual intervention.
 - b. Capable of returning supplied battery(s) from fully discharged to fully charged condition within 36 hours while carrying normal loads.
 - c. Recognized as complying with UL 1236.

- d. Furnished with integral overcurrent protection; current limited to protect charger during engine cranking; reverse polarity protection.
 - e. Provide integral DC output ammeter and voltmeter with five percent accuracy.
 - f. Provide alarm output contacts as necessary for alarm indications.
- F. Engine Speed Control System (Governor):
 - 1. Single Engine Generator Sets (Not Operated in Parallel): Provide electronic isochronous governor for controlling engine speed/alternator frequency.
 - 2. Frequency Regulation, Electronic Isochronous Governors: No change in frequency from no load to full load; plus/minus 0.25 percent at steady state.
- G. Engine Lubrication System:
 - 1. System Type: Full pressure, with engine-driven, positive displacement lubrication oil pump, replaceable full-flow oil filter(s), and dip-stick for oil level indication. Provide oil cooler where recommended by manufacturer.
- H. Engine Cooling System:
 - 1. System Type: Closed-loop, liquid-cooled, with unit-mounted radiator/fan and engine-driven coolant pump; suitable for providing adequate cooling while operating at full load under worst case ambient temperature.
 - 2. Fan Guard: Provide suitable guard to protect personnel from accidental contact with fan.
 - 3. Coolant Heater: Provide thermostatically controlled coolant heater to improve starting under cold ambient conditions; size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature.
- I. Engine Air Intake and Exhaust System:
 - 1. Air Intake Filtration: Provide engine-mounted, replaceable, dry element filter.
 - 2. Engine Exhaust Connection: Provide suitable, approved flexible connector for coupling engine to exhaust system.
 - 3. Exhaust Silencer: Provide critical grade or better exhaust silencer; select according to manufacturer's recommendations to meet sound performance requirements, where specified.

2.4 ALTERNATOR (GENERATOR)

- A. Alternator: 4-pole, 1800 rpm (60 Hz output) revolving field, synchronous generator complying with NEMA MG 1; connected to engine with flexible coupling; voltage output configuration as indicated, with reconnectable leads for 3 phase alternators.
- B. Exciter:

1. Exciter Type: Brushless; provide permanent magnet generator (PMG) excitation system; self-excited (shunt) systems are not permitted.
 2. PMG Excitation Short-Circuit Current Support: Capable of sustaining 300 percent of rated output current for 10 seconds.
 3. Voltage Regulation (with PMG excitation): Plus/minus 0.5 percent for any constant load from no load to full load.
- C. Temperature Rise: Comply with UL 2200.
- D. Insulation System: NEMA MG 1, Class H; suitable for alternator temperature rise.
- E. Enclosure: NEMA MG 1, drip-proof.
- F. Total Harmonic Distortion: Not greater than five percent.

2.5 GENERATOR SET CONTROL SYSTEM

- A. Provide microprocessor-based control system for automatic control, monitoring, and protection of generator set. Include sensors, wiring, and connections necessary for functions/indications specified.
- B. Control Panel:
1. Control Panel Mounting: Unit-mounted unless otherwise indicated; vibration isolated.
 2. Generator Set Control Functions:
 - a. Automatic Mode: Initiates generator set start/shutdown upon receiving corresponding signal from remote device (e.g. automatic transfer switch).
 - b. Manual Mode: Initiates generator set start/shutdown upon direction from operator.
 - c. Reset Mode: Clears all faults, allowing generator set restart after a shutdown.
 - d. Emergency Stop: Immediately shuts down generator set (without time delay) and prevents automatic restarting until manually reset, included in control panel. Provide emergency stop adjacent to utility service disconnect.
 - e. Cycle Cranking: Programmable crank time, rest time, and number of cycles.
 - f. Time Delay: Programmable for shutdown (engine cooldown) and start (engine warmup).
 - g. Voltage Adjustment: Adjustable through range of plus/minus 5 percent.
 3. Generator Set Status Indications:
 - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
 - b. Current (Amps): For each phase.

- c. Frequency (Hz).
 - d. Real power (W/kW).
 - e. Reactive power (VAR/kVAR).
 - f. Apparent power (VA/kVA).
 - g. Power factor.
 - h. Duty Level: Actual load as percentage of rated power.
 - i. Engine speed (RPM).
 - j. Battery voltage (Volts DC).
 - k. Engine oil pressure.
 - l. Engine coolant temperature.
 - m. Engine run time.
 - n. Generator powering load (position signal from transfer switch).
4. Generator Set Protection and Warning/Shutdown Indications:
- a. Comply with the following protections/indications:
 - 1) Overcrank (shutdown).
 - 2) Low coolant temperature (warning).
 - 3) High coolant temperature (warning).
 - 4) High coolant temperature (shutdown).
 - 5) Low oil pressure (warning).
 - 6) Low oil pressure (shutdown).
 - 7) Overspeed (shutdown).
 - 8) Low fuel (warning).
 - 9) Low coolant level (warning/shutdown).
 - 10) Generator control not in automatic mode (warning).
 - 11) High battery voltage (warning).
 - 12) Low cranking voltage (warning).
 - 13) Low battery voltage (warning).

- 14) Battery charger failure (warning).
- b. In addition to the above requirements, provide the following protections/indications:
 - 1) High AC voltage (shutdown).
 - 2) Low AC voltage (shutdown).
 - 3) High frequency (shutdown).
 - 4) Low frequency (shutdown).
 - 5) Overcurrent (shutdown).
 - 6) Fuel tank leak (warning), where applicable.
- c. Provide contacts for local and remote common alarm.
- d. Provide lamp test function that illuminates all indicator lamps.
- 5. Other Control Panel Features:
 - a. Event log.
- C. Remote Annunciator:
 - 1. Remote Annunciator Mounting: Wall-mounted; Provide flush-mounted annunciator for finished areas and surface-mounted annunciator for non-finished areas unless otherwise indicated.
 - 2. Generator Set Status Indications:
 - a. Generator powering load (via position signal from transfer switch).
 - b. Communication functional.
 - 3. Generator Set Warning/Shutdown Indications:
 - a. Comply with NFPA 110 for Optional Standby systems including but not limited to the following indications:
 - 1) Overcrank (shutdown).
 - 2) Low coolant temperature (warning).
 - 3) High coolant temperature (warning).
 - 4) High coolant temperature (shutdown).
 - 5) Low oil pressure (warning).
 - 6) Low oil pressure (shutdown).

- 7) Overspeed (shutdown).
- 8) Low fuel (warning).
- 9) Low coolant level (warning/shutdown).
- 10) Generator control not in automatic mode (warning).
- 11) High battery voltage (warning).
- 12) Low cranking voltage (warning).
- 13) Low battery voltage (warning).
- 14) Battery charger failure (warning).
- b. Provide audible alarm with silence function.
- c. Provide lamp test function that illuminates all indicator lamps.
- 4. Emergency stop within annunciator.
- D. Remote Emergency Stop: Provide approved red, mushroom style remote emergency stop button where indicated or required by authorities having jurisdiction.

2.6 GENERATOR SET ENCLOSURE

- A. Enclosure Type: Sound attenuating, weather protective.
- B. Enclosure Material: Steel or aluminum.
- C. Hardware Material: Stainless steel.
- D. Color: Manufacturer's standard.
- E. Access Doors: Lockable, with all locks keyed alike.
- F. Openings: Designed to prevent bird/rodent entry.
- G. External Drains: Extend oil and coolant drain lines to exterior of enclosure for maintenance service.
- H. Sound Attenuating Enclosures: Line enclosure with non-hydroscopic, self-extinguishing sound-attenuating material.
- I. Utilize an upward discharging radiator hood.
- J. Exhaust Silencers: Where exhaust silencers are mounted within enclosure in main engine compartment, insulate silencer to minimize heat dissipation as necessary for operation at rated load under worst case ambient temperature.
- K. Listed per UL 2200 testing.

2.7 SOURCE QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Perform production tests on generator sets at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.
- C. Generator Set production testing to include, at a minimum:
 - 1. Operation at rated load and rated power factor.
 - 2. Single step load pick-up.
 - 3. Transient and steady state voltage and frequency performance.
 - 4. Operation of safety shutdowns.
- D. Diesel Fuel Storage Tanks: Perform pressurized leak test prior to shipment.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of generator sets and auxiliary equipment are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive equipment.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install generator sets and associated accessories in accordance with NECA/EGSA 404.
- D. Arrange equipment to provide minimum clearances and required maintenance access.
- E. Use manufacturer's recommended oil and coolant, suitable for the worst case ambient temperatures.
- F. Factory Installed:
 - 1. Fuel piping.
 - 2. Exhaust piping.

- 3. Silencer.
- G. Provide grounding and bonding in accordance with Section 26 0526.
- H. Identify system wiring and components in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Provide services of a manufacturer's authorized representative to prepare and start systems and perform inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Notify Owner and Architect/Engineer at least two weeks prior to scheduled inspections and tests.
- D. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- E. Provide all equipment, tools, and supplies required to accomplish inspection and testing, including load bank and fuel.
- F. Preliminary inspection and testing to include, at a minimum:
 - 1. Inspect each system component for damage and defects.
 - 2. Verify tightness of mechanical and electrical connections are according to manufacturer's recommended torque settings.
 - 3. Check for proper oil and coolant levels.
- G. Prepare and start system in accordance with manufacturer's instructions.
- H. Perform acceptance test in accordance with NFPA 110.
- I. Inspection and testing to include, at a minimum:
 - 1. Verify compliance with starting and load acceptance requirements.
 - 2. Verify voltage and frequency; make required adjustments as necessary.
 - 3. Verify phase sequence.
 - 4. Verify control system operation, including safety shutdowns.
 - 5. Verify operation of auxiliary equipment and accessories (e.g. battery charger, heaters, etc.).
 - 6. Perform load tests: 1.5 hour building load test followed by 2 hour full load test.
- J. Provide field emissions testing where necessary for certification.

- K. Sound Level Tests: Measure sound levels for compliance with specified requirements. Identify and report ambient noise conditions.
- L. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- M. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.4 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- C. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of four hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.
- D. After successful acceptance test and just prior to Substantial Completion, replace air, oil, and fuel filters and fill fuel storage tank.

3.6 PROTECTION

- A. Protect installed engine generator system from subsequent construction operations.

END OF SECTION

This page intentionally left blank

SECTION 26 3600 - TRANSFER SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Transfer switches for low-voltage (600 V and less) applications and associated accessories:
 - 1. Automatic transfer switches.

1.2 RELATED REQUIREMENTS

- A. Section 26 3213 - Engine Generators: For interface with transfer switches.
 - 1. Includes code requirements applicable to work of this section.
 - 2. Includes additional testing requirements.
 - 3. Includes related demonstration and training requirements.

1.3 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA ICS 10 Part 1 - Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment 2020.
- D. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- E. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- F. NFPA 110 - Standard for Emergency and Standby Power Systems 2022.
- G. UL 1008 - Transfer Switch Equipment Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate compatibility of transfer switches to be installed with work provided under other sections or by others.
 - 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 4. Coordinate the work with placement of supports, anchors, etc. required for mounting.

5. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.5 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
- B. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.
- C. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- D. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- E. Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.

1.6 QUALITY ASSURANCE

- A. Comply with the following:
 1. NFPA 70 (National Electrical Code).
 2. NEC Article 702 Optional Standby Systems: NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for Optional Standby system, Class 24, Type 10.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store transfer switches in accordance with manufacturer's instructions.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to transfer switch components, enclosure, and finish.

1.8 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Furnish transfer switches and accessories produced by a single manufacturer and obtained from a single supplier.

2.2 TRANSFER SWITCHES

- A. Provide complete power transfer system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Applications:
 - 1. Utilize open transition transfer unless otherwise indicated or required.
- D. Construction Type: Only "contactor type" (open contact) transfer switches are acceptable. Do not use "breaker type" (enclosed contact) transfer switches.
- E. Automatic Transfer Switch:
 - 1. Transfer Switch Type: Automatic transfer switch.
 - 2. Transition Configuration: Open-transition (no neutral position).
 - 3. Voltage: As indicated on the drawings.
 - 4. Ampere Rating: As indicated on the drawings.
 - 5. Neutral Configuration: As indicated on the drawings.
 - 6. Load Served: As indicated on the drawings.
 - 7. Primary Source: As indicated on the drawings.
 - 8. Alternate Source: As indicated on the drawings.
- F. Comply with NEMA ICS 10 Part 1, and list and label as complying with UL 1008 for the classification of the intended application (e.g. optional standby).
- G. Do not use double throw safety switches or other equipment not specifically designed for power transfer applications and listed as transfer switch equipment.

- H. Load Classification: Classified for total system load (any combination of motor, electric discharge lamp, resistive, and tungsten lamp loads with tungsten lamp loads not exceeding 30 percent of the continuous current rating) unless otherwise indicated or required.
- I. Switching Methods:
 - 1. Open Transition:
 - a. Provide break-before-make transfer without a neutral position that is not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
 - 2. Neutral Switching: Use simultaneously switched neutral (break-before-make) method. Overlapping neutral method is not acceptable.
 - 3. Obtain control power for transfer operation from line side of source to which the load is to be transferred.
- J. Service Conditions: Provide transfer switches suitable for continuous operation at indicated ratings under the service conditions at the installed location.
- K. Enclosures:
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - 2. Finish: Manufacturer's standard unless otherwise indicated.
- L. Short Circuit Current Rating:
 - 1. Withstand and Closing Rating: Provide transfer switches, when protected by the supply side overcurrent protective devices to be installed, with listed withstand and closing rating as indicated on the drawings.
- M. Automatic Transfer Switches:
 - 1. Description: Transfer switches with automatically initiated transfer between sources; electrically operated and mechanically held.
 - 2. Control Functions:
 - a. Automatic mode.
 - b. Test Mode: Simulates failure of primary/normal source.
 - c. Voltage and Frequency Sensing:
 - 1) Undervoltage sensing for each phase of primary/normal source; adjustable dropout/pickup settings.

- 2) Undervoltage sensing for alternate/emergency source; adjustable dropout/pickup settings.
- 3) Underfrequency sensing for alternate/emergency source; adjustable dropout/pickup settings.
- d. Outputs:
 - 1) Contacts for engine start/shutdown (except where direct generator communication interface is provided).
 - 2) Auxiliary contacts; one set(s) for each switch position.
- e. Adjustable Time Delays:
 - 1) Engine generator start time delay; delays engine start signal to override momentary primary/normal source failures.
 - 2) Transfer to alternate/emergency source time delay.
 - 3) Retransfer to primary/normal source time delay, with a minimum of a 15-minute delay setting.
 - 4) Engine generator cooldown time delay; delays engine shutdown following retransfer to primary/normal source to permit generator to run unloaded for cooldown period.
- f. Engine Exerciser: Provides programmable scheduled exercising of engine generator selectable with or without transfer to load; provides memory retention during power outage. Coordinate with owner for preferred schedule. Generator shall run under building loads at a minimum of once a month for 2 hours.
- g. Retransfer to Normal Switch: Bypasses time delays for retransfer to primary/normal source.
- 3. Status Indications:
 - a. Connected to alternate/emergency source.
 - b. Connected to primary/normal source.
 - c. Alternate/emergency source available.
 - d. Primary/normal source available.
- 4. Automatic Sequence of Operations:
 - a. Upon failure of primary/normal source for a programmable time period (engine generator start time delay), initiate starting of engine generator where applicable.
 - b. When alternate/emergency source is available, transfer load to alternate/emergency source after programmable time delay.

- c. When primary/normal source has been restored, retransfer to primary/normal source after a programmable time delay. Bypass time delay if alternate/emergency source fails and primary/normal source is available.
 - d. Where applicable, initiate shutdown of engine generator after programmable engine cooldown time delay.
- N. Interface with Other Work:
 - 1. Interface with engine generators 26 3213 Engine Generators.

2.3 SOURCE QUALITY CONTROL

- A. Perform production tests on transfer switches at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of transfer switches are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive transfer switches.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Install transfer switches plumb and level.
- E. Unless otherwise indicated, mount floor-mounted transfer switches on properly sized 3 inch high concrete pad constructed in accordance with plans.

3.3 FIELD QUALITY CONTROL

- A. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Automatic Transfer Switches:

1. Inspect and test in accordance with NETA ATS, except Section 4.
 2. Perform inspections and tests listed in NETA ATS, Section 7.22.3. The insulation-resistance tests listed as optional are not required.
- D. Provide additional inspection and testing as required for completion of associated engine generator testing 26 3213.
 - E. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
 - F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.4 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of transfer switches to Owner, and correct deficiencies or make adjustments as directed.
- C. Training: Train Owner's personnel on operation, adjustment, and maintenance of transfer switches.
 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 2. Provide minimum of four hours of training.
 3. Instructor: Manufacturer's authorized representative.
 4. Location: At project site.
- D. Coordinate with related generator demonstration and training as specified in Section 26 3213.

3.6 PROTECTION

- A. Protect installed transfer switches from subsequent construction operations.

END OF SECTION

This page intentionally left blank

SECTION 26 5100 - INTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Interior luminaires.
- B. Exit signs.
- C. Ballasts and drivers.
- D. Lamps.

1.2 RELATED REQUIREMENTS

- A. Section 26 0529 - Hangers and Supports for Electrical Systems.
- B. Section 26 0533.16 - Boxes for Electrical Systems.
- C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 26 0923 - Lighting Control Devices: Automatic controls for lighting including occupancy sensors.
- E. Section 26 5600 - Exterior Lighting.

1.3 REFERENCE STANDARDS

- A. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources 2021.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA/IESNA 500 - Standard for Installing Indoor Lighting Systems 2006.
- D. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts 2020.
- E. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility 2012 (Reaffirmed 2018).
- F. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- G. NFPA 101 - Life Safety Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 924 - Emergency Lighting and Power Equipment Current Edition, Including All Revisions.
- I. UL 1598 - Luminaires Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
4. Notify Architect/Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Shop Drawings:

1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
2. Provide photometric calculations where luminaires are proposed for substitution.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.

1. LED Luminaires:

- a. Include estimated useful life, calculated based on IES LM-80 test data.

2. Lamps: Include rated life, color temperature, color rendering index (CRI), and initial and mean lumen output.

D. Operation and Maintenance Data: Instructions for each product including information on replacement parts.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 6000 - Product Requirements, for additional provisions.
2. Extra Lenses and Louvers: Two percent of total quantity installed for each type, but not less than one of each type.

- 3. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
- 4. Extra Driver: Two percent of total quantity installed for each type, but not less than one of each type.
- F. Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting) and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.8 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.9 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for LED luminaires, including drivers.
- C. Provide five year pro-rata warranty for batteries for emergency lighting units.
- D. Provide ten year pro-rata warranty for batteries for self-powered exit signs.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.

2.2 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.

- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. Recessed Luminaires:
 - 1. Ceiling Compatibility: Comply with NEMA LE 4.
 - 2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
 - 3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.

2.3 EXIT SIGNS

- A. Description: Internally illuminated exit signs with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
 - 1. Number of Faces: Single or double as indicated or as required for the installed location.
 - 2. Directional Arrows: As indicated or as required for the installed location.
- B. Self-Powered Exit Signs:
 - 1. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
 - 2. Battery: Sealed maintenance-free nickel cadmium unless otherwise indicated.
 - 3. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
 - 4. Provide low-voltage disconnect to prevent battery damage from deep discharge.
 - 5. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.

2.4 BALLASTS AND DRIVERS

- A. Ballasts/Drivers - General Requirements:

1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
 3. Electronic Ballasts/Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.
- B. Dimmable LED Drivers:
1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
 2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.5 LAMPS

- A. Manufacturers:
1. Manufacturer Limitations: Where possible, provide lamps produced by a single manufacturer.
- B. Lamps - General Requirements:
1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
 2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
 3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
 4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Architect/Engineer to be inconsistent in perceived color temperature.

2.6 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.
- C. Provide accessory plaster frames for luminaires recessed in plaster ceilings.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.

- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of luminaires provided under this section.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install products in accordance with manufacturer's instructions.
- D. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting).
- E. Provide required support and attachment in accordance with Section 26 0529.
- F. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- G. Suspended Ceiling Mounted Luminaires:
 - 1. Do not use ceiling tiles to bear weight of luminaires.
 - 2. Do not use ceiling support system to bear weight of luminaires.
 - 3. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.
 - 4. Secure pendant-mounted luminaires to building structure.
 - 5. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
 - 6. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gage, connected from opposing corners of each recessed luminaire to building structure.
- H. Recessed Luminaires:

1. Install trims tight to mounting surface with no visible light leakage.
 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
- I. Suspended Luminaires:
1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet between supports.
 4. Install canopies tight to mounting surface.
 5. Unless otherwise indicated, support pendants from swivel hangers.
- J. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- K. Install accessories furnished with each luminaire.
- L. Bond products and metal accessories to branch circuit equipment grounding conductor.
- M. Exit Signs:
1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- N. Identify luminaires connected to emergency power system in accordance with Section 26 0553.
- O. Install lamps in each luminaire.
- P. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Test self-powered exit signs and emergency lighting units to verify proper operation upon loss of normal power supply.

- E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect/Engineer.

3.5 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect/Engineer. Secure locking fittings in place.
- B. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect/Engineer or authority having jurisdiction.

3.6 CLEANING

- A. Clean surfaces according to NECA 500 (commercial lighting) and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.7 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of luminaires to Architect/Engineer, and correct deficiencies or make adjustments as directed.
- C. Just prior to Substantial Completion, replace all lamps that have failed.

3.8 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Exterior luminaires.
- B. Lamps.
- C. Poles and accessories.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.
- B. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- C. Section 26 0529 - Hangers and Supports for Electrical Systems.
- D. Section 26 0533.16 - Boxes for Electrical Systems.
- E. Section 26 2813 - Fuses.

1.3 REFERENCE STANDARDS

- A. AASHTO LTS - Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals 2013, with Editorial Revision (2022).
- B. IEEE C2 - National Electrical Safety Code(R) (NESC(R)) 2023.
- C. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products 2019.
- D. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources 2021.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- F. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems 2000 (Reaffirmed 2006).
- G. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts 2020.
- H. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility 2012 (Reaffirmed 2018).
- I. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- J. UL 1598 - Luminaires Current Edition, Including All Revisions.
- K. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
2. Notify Architect/Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.5 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Shop Drawings:

1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
2. Provide photometric calculations where luminaires are proposed for substitution upon request.
3. Provide structural calculations for each pole proposed for substitution.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.

1. LED Luminaires:

- a. Include estimated useful life, calculated based on IES LM-80 test data.

2. Lamps: Include rated life and initial and mean lumen output.

3. Poles: Include information on maximum supported effective projected area (EPA) and weight for the design wind speed.

D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 01 6000 - Product Requirements, for additional provisions.
2. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
3. Extra Ballasts: Two percent of total quantity installed for each type, but not less than one of each type.
4. Extra Fuses: Five percent of total quantity installed for each type, but not less than two of each type.

- 5. Touch-Up Paint: 1 gallons, to match color of pole finish.
- E. Project Record Documents: Record actual connections and locations of pole foundations, luminaires, and any pull or junction boxes.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.8 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for all LED luminaires, including drivers.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.

2.2 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Provide products complying with Federal Energy Management Program (FEMP) requirements.
- E. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- F. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.

- G. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- H. Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.
- I. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

2.3 BALLASTS AND DRIVERS

- A. Manufacturers:
 - 1. Manufacturer Limitations: Where possible, for each type of luminaire provide ballasts produced by a single manufacturer.
- B. Ballasts/Drivers - General Requirements:
 - 1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
 - 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
 - 3. Electronic Ballasts/Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.
- C. Dimmable LED Drivers:
 - 1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
 - 2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.4 LAMPS

- A. Manufacturers:
 - 1. Manufacturer Limitations: Where possible, provide lamps produced by a single manufacturer.
- B. Lamps - General Requirements:
 - 1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
 - 2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.

3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Architect/Engineer to be inconsistent in perceived color temperature.

2.5 POLES

A. All Poles:

1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
2. Structural Design Criteria:
 - a. Comply with AASHTO LTS.
 - b. Wind Load: Include effective projected area (EPA) of luminaire(s) and associated supports and accessories to be installed.
 - c. Dead Load: Include weight of proposed luminaire(s) and associated supports and accessories.
3. Material: Aluminum, unless otherwise indicated.
4. Shape: Square straight, unless otherwise indicated.
5. Finish: Match luminaire finish, unless otherwise indicated.
6. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.
7. Unless otherwise indicated, provide with the following features/accessories:
 - a. Handhole.
 - b. Anchor bolts with leveling nuts or leveling shims.

B. Metal Poles: Provide ground lug, accessible from handhole.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.

- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of luminaires provided under this section.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install products in accordance with manufacturer's instructions.
- D. Install luminaires in accordance with NECA/IESNA 501.
- E. Provide required support and attachment in accordance with Section 26 0529.
- F. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- G. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- H. Pole-Mounted Luminaires:
 - 1. Maintain the following minimum clearances:
 - a. Comply with IEEE C2.
 - b. Comply with utility company requirements.
 - 2. Foundation-Mounted Poles:
 - a. Provide cast-in-place concrete foundations for poles as indicated, in accordance with Section 03 3000.
 - 1) Install anchor bolts plumb per template furnished by pole manufacturer.
 - 2) Position conduits to enter pole shaft.
 - b. Install foundations plumb.
 - c. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
 - d. Tighten anchor bolt nuts to manufacturer's recommended torque.

- e. Install non-shrink grout between pole anchor base and concrete foundation, leaving small channel for condensation drainage.
- f. Install anchor base covers or anchor bolt covers as indicated.
- 3. Grounding:
 - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
 - b. Provide supplementary ground rod electrode as specified in Section 26 0526 at each pole bonded to grounding system as indicated.
- 4. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.
- 5. Install non-breakaway in-line fuse holders and fuses complying with Section 26 2813 in pole handhole for each ungrounded conductor.
- I. Install accessories furnished with each luminaire.
- J. Bond products and metal accessories to branch circuit equipment grounding conductor.
- K. Install lamps in each luminaire.

3.4 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect/Engineer.

3.5 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect/Engineer. Secure locking fittings in place.
- B. Luminaires with Field-Rotatable Optics: Position optics according to manufacturer's instructions to achieve lighting distribution as indicated or as directed by Architect/Engineer.

3.6 CLEANING

- A. Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.7 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of luminaires to Architect/Engineer, and correct deficiencies or make adjustments as directed.
- C. Just prior to Substantial Completion, replace all lamps that have failed.

3.8 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

SECTION 27 0529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other communications work.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 26 0529 - Hangers and Supports for Electrical Systems.
- C. Section 27 1000 - Structured Cabling.

1.3 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2023.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2023.
- D. BICSI ITSIMM - Information Technology Systems Installation Methods Manual (ITSIMM), 8th Edition 2022.
- E. BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition 2019.
- F. MFMA-4 - Metal Framing Standards Publication 2004.
- G. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. TIA-569 - Telecommunications Pathways and Spaces 2019e.
- J. UL 5B - Strut-Type Channel Raceways and Fittings Current Edition, Including All Revisions.
- K. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
 2. Coordinate work to provide additional framing and materials required for installation.
 3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
 4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
 5. Notify Architect/Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
1. Do not install products on or provide attachment to concrete surfaces until concrete has cured; see Section 03 3000.

1.5 QUALITY ASSURANCE

- A. Product Listing Organization Qualifications: Organization recognized by OSHA as Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
1. Comply with the following. Where requirements differ, comply with most stringent.
 - a. TIA-569.
 - b. NFPA 70.
 - c. Applicable building code.
 - d. Requirements of authorities having jurisdiction.
 2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of communications work.
 3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
 4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported

with minimum safety factor of 125%. Include consideration for vibration, equipment operation, and shock loads where applicable.

5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
 6. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
 7. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Conduit Supports: Straps and clamps suitable for conduit to be supported.
1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Cable Supports: Suitable for cables to be supported, including but not limited to J-hooks, bridle rings, drive rings, and flexible harnesses/slings.
1. Applications:
 - a. Do not exceed 5 feet between cable supports.
 - b. Maximum Number of Cables per Cable Support:
 - 1) J-Hooks: 50, regardless of capacity.
 - c. Allowable Cable Types:
 - 1) J-Hooks: Category 6.
 - 2) Bridle Rings with Saddle: Category 6.
 2. Comply with TIA-569.
 3. Cable Supports Installed in Spaces Used for Environmental Air: Plenum rated; listed and labeled as complying with UL 2043, suitable for use in air-handling spaces.
 4. J-Hooks: Noncontinuous cabling support with removable top retainer clip.

- a. Material: Use galvanized steel, factory-painted steel, or stainless steel.
 - b. Provide support surfaces with smooth, beveled edges and radius not less than minimum allowable bend radius of cables supported.
 - c. Provide multitiered J-hooks where required to support multiple cabling systems.
- 5. Bridle rings: Noncontinuous circular cabling support.
 - a. Material: Use galvanized steel, painted steel, or stainless steel.
 - b. Provide integral saddle with smooth, beveled edges and radius not less than minimum allowable bend radius of cables supported where indicated.
- D. Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.
- E. Metal Channel/Strut Framing Systems:
 - 1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
 - 2. Comply with MFMA-4.
 - 3. Channel/Strut Used as Raceway, Where Indicated: Listed and labeled as complying with UL 5B.
 - 4. Channel Material:
 - a. Indoor Dry Locations: Use zinc-plated steel or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 - 5. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
 - 6. Minimum Channel Dimensions: 1-5/8 inch wide by 13/16 inch high.
- F. Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.
 - 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2-inch diameter.
 - b. Single Conduit up to 1-inch (27 mm) Trade Size: 1/4-inch diameter.
 - c. Single Conduit Larger than 1-inch (27 mm) Trade Size: 3/8-inch diameter.
 - d. Trapeze Support for Multiple Conduits: 3/8-inch diameter.
 - e. Outlet Boxes: 1/4-inch diameter.
- G. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.
2. Concrete: Use expansion anchors or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Sheet Metal: Use sheet metal screws.
8. Plastic and lead anchors are not permitted.
9. Powder-actuated fasteners are not permitted.
10. Hammer-driven anchors and fasteners are not permitted.
11. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install hangers and supports in accordance with NECA 1, BICSI ITSIMM, and BICSI N1.
- C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- D. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- E. Unless specifically indicated or approved by Architect/Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- F. Unless specifically indicated or approved by Architect/Engineer, do not provide support from roof deck.

- G. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- H. Equipment Support and Attachment:
 - 1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
 - 2. Use metal channel/strut secured to studs to support equipment surface mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- I. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- J. Secure fasteners in accordance with manufacturer's recommended torque settings.
- K. Remove temporary supports.
- L. Identify independent communications component support wires above accessible ceilings, where permitted, with color distinguishable from other support wires in accordance with NFPA 70.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 27 1000 - STRUCTURED CABLING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Communications system design requirements.
- B. Communications pathways.
- C. Copper cable and terminations.
- D. Communications equipment room fittings.
- E. Communications outlets.
- F. Communications grounding and bonding.
- G. Communications identification.

1.2 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 26 0526 - Grounding and Bonding for Electrical Systems.
 - 1. Includes intersystem bonding termination.
 - 2. Includes bonding jumpers for bonding of communications systems and electrical system grounding.
- C. Section 26 0533.13 - Conduit for Electrical Systems.
- D. Section 26 0536 - Cable Trays for Electrical Systems.
- E. Section 26 0533.16 - Boxes for Electrical Systems.
- F. Section 26 0553 - Identification for Electrical Systems: Identification products.
- G. Section 26 2726 - Wiring Devices.

1.3 REFERENCE STANDARDS

- A. EIA/ECA-310 - Cabinets, Racks, Panels, and Associated Equipment 2005e.
- B. NFPA 70 - National Electric Code; National Fire Protection Association; 2017.
- C. TIA-568 (SET) - Commercial Building Telecommunications Cabling Standard Set 2020.
- D. TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards 2018d, with Addenda (2020).
- E. TIA-570 - Residential Telecommunications Infrastructure Standard 2018d.

- F. TIA-606 - Administration Standard for Telecommunications Infrastructure 2021d.
- G. TIA-607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises 2019d.
- H. UL 444 - Communications Cables Current Edition, Including All Revisions.
- I. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers Current Edition, Including All Revisions.
- J. UL 1863 - Communications-Circuit Accessories Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate requirements for service entrance and entrance facilities with Communications Service Provider.
 - 2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for communications equipment.
 - 3. Coordinate arrangement of communications equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 4. Notify Architect/Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Owner shall arrange for Communications Service Provider to provide service, including cost.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- C. Shop Drawings: Show compliance with requirements on isometric schematic diagram of network layout, showing cable routings, telecommunication closets, rack and enclosure layouts and locations, service entrance, and grounding, prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
- D. Evidence of qualifications for installer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- F. Project Record Documents: Prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
 - 1. Record actual locations of outlet boxes and distribution frames.

2. Show as-installed color coding, pair assignment, polarization, and cross-connect layout.
 3. Identify distribution frames and equipment rooms by room number on drawings.
- G. Operation and Maintenance Data: List of all components with part numbers, sources of supply, and operation and maintenance instructions; include copy of project record documents.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A company having at least 3 years experience in the installation and testing of the type of system specified, and:
1. Employing a BICSI Registered Communications Distribution Designer (RCDD).
 2. Supervisors and installers factory certified by manufacturers of products to be installed.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Keep stored products clean and dry.

1.8 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a 2 year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.1 SYSTEM DESIGN

- A. Provide a complete permanent system of cabling and pathways for voice and data communications, including cables, conduits and wireways, pull wires, support structures, enclosures and cabinets, and outlets.
1. Provide fixed cables and pathways that comply with NFPA 70 and TIA-607 and are UL listed or third party independent testing laboratory certified.
 2. Provide connection devices that are rated for operation under conditions of 32 to 140 degrees F at relative humidity of 0 to 95 percent, noncondensing.
 3. In this project, the term plenum is defined as return air spaces above ceilings, inside ducts, under raised floors, and other air-handling spaces.

- B. Main Distribution Frame (MDF): Centrally located support structure for terminating horizontal cables that extend to telecommunications outlets, functioning as point of presence to external service provider.
 - 1. Locate main distribution frame as indicated on the drawings.
 - 2. Capacity: As required to terminate all cables required by design criteria plus minimum 25 percent spare space.
- C. Cabling to Outlets: Specified horizontal cabling, wired in star topology to distribution frame located at center hub of star; also referred to as "links".

2.2 PATHWAYS

- A. Conduit: As specified in Section 26 0533.13; provide pull cords in all conduit.
- B. Cable Trays: As specified in Section 26 0536.
- C. Underground Service Entrance: Rigid polyvinyl chloride (PVC) conduit, Schedule 40.

2.3 COPPER CABLE AND TERMINATIONS

- A. Copper Horizontal Cable:
 - 1. Description: 100 ohm, balanced twisted pair cable complying with TIA-568.2 and listed and labeled as complying with UL 444.
 - 2. Cable Type - Voice and Data: TIA-568.2 Category 6 UTP (unshielded twisted pair); 23 AWG.
 - 3. Cable Capacity: 4-pair.
 - 4. Cable Applications: Use listed NFPA 70 Type CMP plenum cable unless otherwise indicated.
 - 5. Cable Jacket Color - Voice and Data Cable: Blue.
- B. Copper Cable Terminations: Insulation displacement connection (IDC) type using appropriate tool; use screw connections only where specifically indicated.
- C. Jacks and Connectors: Modular RJ-45, non-keyed, terminated with 110-style insulation displacement connectors (IDC); high impact thermoplastic housing; suitable for and complying with same standard as specified horizontal cable; UL 1863 listed.
 - 1. Performance: 500 mating cycles.
 - 2. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.
- D. Copper Patch Cords:

1. Description: Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end.
2. Patch Cords for Patch Panels:
 - a. Quantity: One for each pair of patch panel ports.
 - b. Length: 1 feet.

2.4 COMMUNICATIONS EQUIPMENT ROOM FITTINGS

A. Copper Cross-Connection Equipment:

1. Connector Blocks for Category 5e and Up Cabling: Type 110 insulation displacement connectors; capacity sufficient for cables to be terminated plus 25 percent spare.
2. Patch Panels for Copper Cabling: Sized to fit EIA/ECA-310 standard 19 inch wide equipment racks; 0.09 inch thick aluminum; cabling terminated on Type 110 insulation displacement connectors; printed circuit board interface.
 - a. Jacks: Non-keyed RJ-45, suitable for and complying with same standard as cable to be terminated; maximum 48 ports per standard width panel.
 - b. Capacity: Provide ports sufficient for cables to be terminated plus 25 percent spare.
 - c. Labels: Factory installed laminated plastic nameplates above each port, numbered consecutively; comply with TIA-606.
 - d. Provide incoming cable strain relief and routing guides on back of panel.

B. Backboards: Interior grade plywood without voids, 3/4 inch thick; UL-labeled fire-retardant.

1. Size: As indicated on drawings.
2. Do not paint over UL label.

C. Equipment Frames, Racks and Cabinets:

1. Component Racks: EIA/ECA-310 standard 19 inch wide.
2. Floor Mounted Racks: Aluminum or steel construction with corrosion resistant finish; vertical and horizontal cable management channels, top and bottom cable troughs, and grounding lug.
3. Cabinets: Steel construction with corrosion resistant finish.
4. Locks: Keyed alike.

2.5 COMMUNICATIONS OUTLETS

A. Outlet Boxes: Comply with Section 26 0533.16.

1. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.
 2. Minimum Size, Unless Otherwise Indicated:
 - a. Voice Only Outlets: 4 inch by 2 inch by 2-1/8 inch deep (100 by 50 by 54 mm) trade size.
 - b. Data or Combination Voice/Data Outlets: 4 inch square by 2-1/8 inch deep (100 by 54 mm) trade size.
- B. Wall Plates:
1. Comply with system design standards and UL 514C.
 2. Accepts modular jacks/inserts.
 3. Capacity:
 - a. Data or Combination Voice/Data Outlets: as indicated on the plans.
 4. Wall Plate Material/Finish - Flush-Mounted Outlets: Match wiring device and wall plate finishes specified in Section 26 2726.

2.6 GROUNDING AND BONDING COMPONENTS

- A. Comply with TIA-607.
- B. Comply with Section 26 0526.

2.7 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606.
- B. Comply with Section 26 0553.

2.8 SOURCE QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Factory test cables according to TIA-568 (SET).

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

- A. Comply with latest editions and addenda of TIA-568 (SET) (cabling), TIA-569 (pathways), TIA-607 (grounding and bonding), NECA/BICSI 568, NFPA 70, and SYSTEM DESIGN as specified in PART 2.
- B. Comply with latest editions and addenda of TIA-570, TIA-607, NFPA 70, and SYSTEM DESIGN as specified in PART 2.

- C. Comply with Communication Service Provider requirements.
- D. Grounding and Bonding: Perform in accordance with TIA-607 and NFPA 70.
- E. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

3.2 INSTALLATION OF PATHWAYS

- A. Install pathways with the following minimum clearances:
 - 1. 48 inches from motors, generators, frequency converters, transformers, x-ray equipment, and uninterruptible power systems.
 - 2. 12 inches from power conduits and cables and panelboards.
 - 3. 5 inches from fluorescent and high frequency lighting fixtures.
 - 4. 6 inches from flues, hot water pipes, and steam pipes.
- B. Conduit, in Addition to Requirements of Section 26 0533.13:
 - 1. Arrange conduit to provide no more than the equivalent of two 90 degree bend(s) between pull points.
 - 2. Conduit Bends: Inside radius not less than 10 times conduit internal diameter.
 - 3. Arrange conduit to provide no more than 100 feet between pull points.
 - 4. Do not use conduit bodies.
 - 5. Minimum Cover - Underground Service Entrance: Comply with NFPA 70 and Communications Service Provider requirements.
- C. Outlet Boxes:
 - 1. Coordinate locations of outlet boxes provided under Section 26 0533.16 as required for installation of telecommunications outlets provided under this section.
 - a. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
 - b. Provide minimum of 24 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.
 - c. Unless otherwise indicated, provide separate outlet boxes for line voltage and low voltage devices.
 - d. Locate outlet boxes so that wall plate does not span different building finishes.
 - e. Locate outlet boxes so that wall plate does not cross masonry joints.
 - f. Locate adjacent to power receptacles where intended to be.

3.3 INSTALLATION OF EQUIPMENT AND CABLING

A. Cabling:

1. Do not bend cable at radius less than manufacturer's recommended bend radius; for unshielded twisted pair use bend radius of not less than 4 times cable diameter.
2. Do not over-cinch or crush cables.
3. Do not exceed manufacturer's recommended cable pull tension.
4. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.

B. Service Loops (Slack or Excess Length): Provide the following minimum extra length of cable, looped neatly:

1. At Distribution Frames: 120 inches.
2. At Outlets - Copper: 12 inches.

C. Copper Cabling:

1. Category 5e and Above: Maintain cable geometry; do not untwist more than 1/2 inch from point of termination.
2. For 4-pair cables in conduit, do not exceed 25 pounds pull tension.
3. Use T568B wiring configuration.

D. Floor-Mounted Racks and Enclosures: Permanently anchor to floor in accordance with manufacturer's recommendations.

E. Identification:

1. Use wire and cable markers to identify cables at each end.
2. Use manufacturer-furnished label inserts, identification labels, or engraved wallplate to identify each jack at communications outlets with unique identifier.
3. Use identification nameplate to identify cross-connection equipment, equipment racks, and cabinets.

3.4 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Comply with inspection and testing requirements of specified installation standards.

C. Visual Inspection:

1. Inspect cable jackets for certification markings.

2. Inspect cable terminations for color coded labels of proper type.
 3. Inspect outlet plates and patch panels for complete labels.
 4. Inspect patch cords for complete labels.
- D. Testing - Copper Cabling and Associated Equipment:
1. Test operation of shorting bars in connection blocks.
 2. Category 5e and Above Backbone: Perform near end cross talk (NEXT) and attenuation tests.
 3. Category 5e and Above Links: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.
- E. Final Testing: After all work is complete, including installation of telecommunications outlets, and telephone dial tone service is active, test each voice jack for dial tone.

END OF SECTION

This page intentionally left blank

SECTION 28 4600 - FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fire alarm system design and installation, including all components, wiring, and conduit.
- B. Transmitters for communication with supervising station.
- C. Fire-alarm control unit.
- D. Manual fire-alarm boxes.
- E. System smoke detectors.
- F. Notification appliances.
- G. Device guards.
- H. Remote annunciator.
- I. Addressable interface device.
- J. Digital alarm communicator transmitter.
- K. Maintenance of fire alarm system under contract for specified warranty period.

1.2 RELATED REQUIREMENTS

- A. Section 21 1300 - Fire-Suppression Sprinkler Systems: Supervisory, alarm, and actuating devices installed in sprinkler system.
- B. Section 23 3300 - Air Duct Accessories: Smoke dampers monitored and controlled by fire alarm system.
- C. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- D. Section 26 0553 - Identification for Electrical Systems.

1.3 REFERENCE STANDARDS

- A. 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines current edition.
- B. ADA Standards - 2010 ADA Standards for Accessible Design 2010.
- C. IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits 2002 (Corrigendum 2012).
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2017.

- E. NFPA 72 - National Fire Alarm and Signaling Code Most Recent Edition Cited by Referring Code or Reference Standard.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- C. Evidence of designer qualifications.
- D. Design Documents: Submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, and description of operation:
 - 1. Copy (if any) of list of data required by authority having jurisdiction.
 - 2. NFPA 72 "Record of Completion", filled out to the extent known at the time.
 - 3. Clear and concise description of operation, with input/output matrix similar to that shown in NFPA 72 Appendix A-7-5-2.2(9), and complete listing of software required.
 - 4. System zone boundaries and interfaces to fire safety systems.
 - 5. Location of all components, circuits, and raceways; mark components with identifiers used in control unit programming.
 - 6. Circuit layouts; number, size, and type of raceways and conductors; conduit fill calculations; spare capacity calculations; notification appliance circuit voltage drop calculations.
 - 7. List of all devices on each signaling line circuit, with spare capacity indicated.
 - 8. Manufacturer's detailed data sheet for each component, including wiring diagrams, installation instructions, and circuit length limitations.
 - 9. Description of power supplies; if secondary power is by battery include calculations demonstrating adequate battery power.
 - 10. Include voltage drop calculations for notification-appliance circuits.
 - 11. Include battery-size calculations.
- E. Evidence of installer qualifications.
- F. Inspection and Test Reports:
 - 1. Submit inspection and test plan prior to closeout demonstration.

2. Submit documentation of satisfactory inspections and tests.
 3. Submit NFPA 72 "Inspection and Test Form," filled out.
- G. Operating and Maintenance Data: See Section 01 7800 for additional requirements; revise and resubmit until acceptable; have one set available during closeout demonstration:
1. Complete set of specified design documents, as approved by authority having jurisdiction.
 2. Additional printed set of project record documents and closeout documents, bound or filed in same manuals.
 3. Contact information for firm that will be providing contract maintenance and trouble call-back service.
 4. List of recommended spare parts (specific model numbers), tools, and instruments for testing.
 5. Replacement parts list (specific model numbers) with current prices and source of supply.
 6. Detailed troubleshooting guide and large scale input/output matrix.
 7. Preventive maintenance, inspection, and testing schedule complying with NFPA 72; provide printed copy and computer format acceptable to Owner.
 8. Detailed but easy to read explanation of procedures to be taken by non-technical administrative personnel in the event of system trouble, when routine testing is being conducted, for fire drills, and when entering into contracts for remodeling.
- H. Project Record Documents: See Section 01 7800 for additional requirements; have one set available during closeout demonstration:
1. Complete set of floor plans showing actual installed locations of components, conduit, and zones.
 2. "As installed" wiring and schematic diagrams, with final terminal identifications.
 3. "As programmed" operating sequences, including control events by device, updated input/output chart, and voice messages by event.
- I. Closeout Documents:
1. Certification by manufacturer that the system has been installed in compliance with manufacturer's installation requirements, is complete, and is in satisfactory operating condition.
 2. NFPA 72 "Record of Completion", filled out completely and signed by installer and authorized representative of authority having jurisdiction.
 3. Certificate of Occupancy.

4. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
 5. Riser diagram.
 6. Device addresses.
 7. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - a. Equipment tested.
 - b. Frequency of testing of installed components.
 - c. Frequency of inspection of installed components.
 - d. Requirements and recommendations related to results of maintenance.
 - e. Manufacturer's user training manuals.
 8. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.
 9. Software operating and upgrade manuals.
 10. Program Software Backup: On magnetic media or compact disk, complete with data files.
 11. Device address list.
 12. Printout of software application and graphic screens.
- J. Maintenance Materials, Tools, and Software: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 6000 - Product Requirements, for additional provisions.
 2. Furnish spare parts of same manufacturer and model as those installed; deliver in original packaging, labeled in same manner as in operating and maintenance data.
 3. In addition to the items in quantities indicated in PART 2, furnish the following:
 - a. All tools, software, and documentation necessary to modify the fire alarm system using Owner's personnel; minimum modification capability to include addition and deletion of devices, circuits, and zones, and changes to system description, operation, and evacuation and instructional messages.
 - b. One copy, on CD-ROM, of all software not resident in read-only-memory.
 - c. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.

- d. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
 - e. Smoke Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
 - f. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
 - g. Keys and Tools: One extra set for access to locked or tamperproofed components.
 - h. Audible and Visual Notification Appliances: One of each type installed.
 - i. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
- K. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- 1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
 - 2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.

1.5 QUALITY ASSURANCE

- A. Copies of Design Criteria Documents: Maintain at the project site for the duration of the project, bound together, an original copy of NFPA 72, the relevant portions of applicable codes, and instructions and guidelines of authorities having jurisdiction; deliver to Owner upon completion.
- B. Designer Qualifications: NICET Level III or IV (3 or 4) certified fire alarm technician or registered fire protection engineer, employed by fire alarm control panel manufacturer, Contractor, or installer .
- C. Installer Qualifications: Firm with minimum 3 years documented experience installing fire alarm systems of the specified type and providing contract maintenance service as a regular part of their business.
 - 1. Installer Personnel: At least 2 years of experience installing fire alarm systems.
 - 2. Supervisor: NICET level III or IV (3 or 4) certified fire alarm technician; furnish name and address.
 - 3. Certified in the State in which the Project is located as fire alarm installer.

- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 PROJECT CONDITIONS

- A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction. Devices used during construction shall be cleaned and tested prior to Substantial Completion.

1.7 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide control panel manufacturer's warranty that system components other than wire and conduit are free from defects and will remain so for 1 year after date of Substantial Completion.
- C. Provide installer's warranty that the installation is free from defects and will remain so for 1 year after date of Substantial Completion.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.
- B. Automatic sensitivity control of certain smoke detectors.
- C. All components provided shall be listed for use with the selected system.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. All components provided shall be by the same supplier and manufacturer.

2.2 FIRE ALARM SYSTEM

- A. Fire Alarm System: Provide a new automatic fire detection and alarm system:
 - 1. Provide all components necessary, regardless of whether shown in Contract Documents or not.
 - 2. Protected Premises: Entire building shown on drawings.
 - 3. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:
 - a. ADA Standards.
 - b. The requirements of the State Fire Marshal.

- c. The requirements of the local authority having jurisdiction .
 - d. Applicable local codes.
 - e. Contract Documents (drawings and specifications).
 - f. NFPA 72; where the word "should" is used consider that provision mandatory; where conflicts between requirements require deviation from NFPA 72, identify deviations clearly on design documents.
- 4. Evacuation Alarm: Multiple smoke zones; allow for evacuation notification of any individual zone or combination of zones, in addition to general evacuation of entire premises.
 - 5. General Evacuation Zones: Each smoke zone is considered a general evacuation zone unless otherwise indicated, with alarm notification in all zones on the same floor, on the floor above, and the floor below.
 - 6. Hearing Impaired Occupants: Provide visible notification devices in all public areas and in dwelling units.
 - 7. Fire Alarm Control Unit: New, location as indicated on plans.
 - 8. Combined Systems: Do not combine fire alarm system with other non-fire systems.
- B. Supervising Stations and Fire Department Connections:
- 1. Public Fire Department Notification: By remote supervising station.
 - 2. Remote Supervising Station: UL-listed central station under contract to facility.
 - 3. Means of Transmission to Remote Supervising Station: Digital alarm communicator transmitter (DACT), 2 telephone lines.
 - 4. Auxiliary Connection Type: Local energy.
- C. Circuits:
- 1. Initiating Device Circuits (IDC): Class B, Style A.
 - 2. Signaling Line Circuits (SLC) Within Single Building: Class B, Style 0.5.
 - 3. Signaling Line Circuits (SLC) Between Buildings: Class A, Style 2.
 - 4. Notification Appliance Circuits (NAC): Class B, Style W.
- D. Spare Capacity:
- 1. Initiating Device Circuits: Minimum 25 percent spare capacity.
 - 2. Notification Appliance Circuits: Minimum 25 percent spare capacity.

3. Fire Alarm Control Units: Capable of handling all circuits utilized to capacity without requiring additional components other than plug-in control modules.
- E. Power Sources:
1. Primary: Dedicated branch circuits of the facility power distribution system; 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by 24-V dc source.
 - a. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
 2. Secondary: Storage batteries.
 - a. Batteries: Sealed lead calcium.
 3. Capacity: Sufficient to operate entire system for period specified by NFPA 72.
 4. Each Computer System: Provide uninterruptible power supply (UPS).

2.3 FIRE SAFETY SYSTEMS INTERFACES

- A. Supervision: Provide supervisory signals in accordance with NFPA 72 for the following:
1. Sprinkler water control valves.
 2. Dry-pipe sprinkler system pressure (high or low).
 3. Dry-pipe sprinkler valve room low temperature.
 4. Loss of communication with any panel on the network.
- B. Alarm:
1. Provide alarm initiation in accordance with NFPA 72 for the following:
 - a. Sprinkler water flow.
 - b. Manual stations.
 - c. Smoke detectors.
 - d. Fire standpipe system.
 - e. Dry system pressure flow switch.
 - f. Duct smoke detectors.
 2. Fire-alarm signal shall initiate the following actions:
 - a. Continuously operate alarm notification appliances.

- b. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels and remote annunciators.
 - c. Transmit an alarm signal to the remote alarm receiving station.
 - d. Unlock electric door locks in designated egress paths.
 - e. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - f. Record events in the system memory.
- 3. System trouble signal initiation shall be by one or more of the following devices and actions:
 - a. Open circuits, shorts, and grounds in designated circuits.
 - b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - c. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
 - d. Loss of primary power at fire-alarm control unit.
 - e. Ground or a single break in internal circuits of fire-alarm control unit.
 - f. Abnormal ac voltage at fire-alarm control unit.
 - g. Break in standby battery circuitry.
 - h. Failure of battery charging.
 - i. Abnormal position of any switch at fire-alarm control unit or annunciator.
- 4. System Supervisory Signal Actions:
 - a. Initiate notification appliances.
 - b. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels and remote annunciators.
 - c. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

C. HVAC:

- 1. Duct Smoke Detectors: Close dampers indicated; shut down air handlers indicated.

2.4 COMPONENTS

A. General:

1. Provide flush mounted units where installed in finish areas; in unfinished areas, surface mounted unit are acceptable.
 2. Provide legible, permanent labels for each control device, using identification used in operation and maintenance data.
- B. Fire Alarm Control Units: Analog, addressable type; listed, classified, and labeled as suitable for the purpose intended.
- C. Master Fire-Alarm Control Unit (FACP):
1. General Requirements:
 - a. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - 1) System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - 2) Include a real-time clock for time annotation of events on the event recorder and printer.
 - 3) Provide communication between the FACP and remote circuit interface panels, and annunciators.
 - 4) The FACP shall be listed for connection to a central-station signaling system service.
 - 5) Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
 - b. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
 - c. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
 2. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 - a. Annunciator and Display: Liquid-crystal type, one line of 40 characters, minimum.
 - b. 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.

3. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
 - a. Pathway Class Designations: NFPA 72, Class A.
 - b. Pathway Survivability: Level 0.
 - c. Install no more than 50 addressable devices on each signaling-line circuit.
 - d. Serial Interfaces:
 - 1) One dedicated RS 485 port for remote station operation using point ID DACT.
 4. Smoke-Alarm Verification:
 - a. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
 - b. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
 - c. Record events by the system printer.
 - d. Sound general alarm if the alarm is verified.
 5. Notification-Appliance Circuit:
 - a. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
 - b. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
 6. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
 7. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- D. Initiating Devices:
1. Addressable Systems:
 - a. Addressable Devices: Individually identifiable by addressable fire alarm control unit.
 - b. Provide suitable addressable interface modules as indicated or as required for connection to conventional (non-addressable) devices and other components that provide a dry closure output.

2. Manual Pull Stations: Comply with UL 38.
 - a. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1) Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 - 2) Station Reset: Key- or wrench-operated switch.
3. System Smoke Detectors: Comply with UL 268; operating at 24-V dc, nominal.
 - a. General Requirements for System Smoke Detectors:
 - 1) Detectors shall be four-wire type.
 - 2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 3) Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - 4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 5) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
 - 6) Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - (a) Multiple levels of detection sensitivity for each sensor.
 - (b) Sensitivity levels based on time of day.
 - b. Photoelectric Smoke Detectors:
 - 1) Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 - 2) An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

- (a) Primary status.
 - (b) Device type.
 - (c) Present average value.
 - (d) Present sensitivity selected.
 - (e) Sensor range (normal, dirty, etc.).
- c. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
 - 1) Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 - 2) An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - (a) Primary status.
 - (b) Device type.
 - (c) Present average value.
 - (d) Present sensitivity selected.
 - (e) Sensor range (normal, dirty, etc.).
 - 3) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
 - 4) Each sensor shall have multiple levels of detection sensitivity.
 - 5) Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
 - 6) Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.
- 4. Addressable Interface Devices:
 - a. General:
 - 1) Include address-setting means on the module.
 - 2) Store an internal identifying code for control panel use to identify the module type.
 - 3) Listed for controlling HVAC fan motor controllers.
 - b. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

- c. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.
 - 1) Allow the control panel to switch the relay contacts on command.
 - 2) Have a minimum of two normally open and two normally closed contacts available for field wiring.
 - d. Control Module:
 - 1) Operate notification devices.
 - 2) Operate solenoids for use in sprinkler service.
- E. Notification Appliances:
- 1. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
 - a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
 - 2. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol. Provide wire guards in prisoner pathways and holding areas.
 - 3. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens. Provide wire guards in prisoner pathways and holding areas.
 - a. Rated Light Output:
 - 1) 15/30/75/110 cd, selectable in the field.
 - b. Mounting: Wall mounted unless otherwise indicated.
 - c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place. Provide wire guards in prisoner pathways and holding areas.
 - d. Flashing shall be in a temporal pattern, synchronized with other units.
 - e. Strobe Leads: Factory connected to screw terminals.
 - f. Mounting Faceplate: Factory finished, red.
- F. Circuit Conductors: Copper or optical fiber; provide 200 feet extra; color code and label.

- G. Surge Protection: In accordance with IEEE C62.41.2 category B combination waveform and NFPA 70; except for optical fiber conductors.
 - 1. Equipment Connected to Alternating Current Circuits: Maximum let through voltage of 350 V(ac), line-to-neutral, and 350 V(ac), line-to-line; do not use fuses.
 - 2. Initiating Device Circuits, Notification Appliance Circuits, and Communications Circuits: Provide surge protection at each point where circuit exits or enters a building; rated to protect applicable equipment; for 24 V(dc) maximum dc clamping voltage of 36 V(dc), line-to-ground, and 72 V(dc), line-to-line.
 - 3. Signaling Line Circuits: Provide surge protection at each point where circuit exits or enters a building, rated to protect applicable equipment.
- H. Locks and Keys: Deliver keys to Owner.
 - 1. Provide the same standard lock and key for each key operated switch and lockable panel and cabinet.
 - 2. Provide a different standard lock and key for each operated alarm initiating device.
- I. Instruction Charts: Printed instruction chart for operators, showing steps to be taken when a signal is received (normal, alarm, supervisory, and trouble); easily readable from normal operator's station.
 - 1. Frame: Stainless steel or aluminum with polycarbonate or glass cover.
 - 2. Provide one for each control unit where operations are to be performed.
 - 3. Obtain approval of Owner prior to mounting; mount in location acceptable to Owner.
 - 4. Provide extra copy with operation and maintenance data submittal.
- J. Remote Annunciator
 - 1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
 - a. Mounting: Flush cabinet, NEMA 250, Type 1.
 - 2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with applicable codes, NFPA 72, NFPA 70, and Contract Documents.
- B. Conceal all wiring, conduit, boxes, and supports where installed in finished areas.

- C. Obtain Owner's approval of locations of devices, before installation.
- D. Install instruction cards and labels.
- E. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
- F. Manual Fire-Alarm Boxes:
 - 1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
 - 2. Mount manual fire-alarm box on a background of a contrasting color.
 - 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- G. Smoke- or Heat-Detector Spacing:
 - 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
 - 2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 - 3. Smooth ceiling spacing shall not exceed 30 feet.
 - 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
 - 5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
 - 6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- H. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- I. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
 - 1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- J. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, duct smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

- K. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- M. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 INSPECTION AND TESTING FOR COMPLETION

- A. Notify Owner 7 days prior to beginning completion inspections and tests.
- B. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- C. Provide the services of the installer's supervisor or person with equivalent qualifications to supervise inspection and testing, correction, and adjustments.
- D. Visual Inspection: Conduct visual inspection prior to testing.
 - 1. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - 2. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
- E. Prepare for testing by ensuring that all work is complete and correct; perform preliminary tests as required.
- F. Provide all tools, software, and supplies required to accomplish inspection and testing.
- G. Perform inspection and testing in accordance with NFPA 72 and requirements of local authorities; document each inspection and test.
- H. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- I. Diagnostic Period: After successful completion of inspections and tests, Operate system in normal mode for at least 14 days without any system or equipment malfunctions.
 - 1. Record all system operations and malfunctions.
 - 2. If a malfunction occurs, start diagnostic period over after correction of malfunction.
 - 3. Owner will provide attendant operator personnel during diagnostic period; schedule training to allow Owner personnel to perform normal duties.
 - 4. At end of successful diagnostic period, fill out and submit NFPA 72 "Inspection and Testing Form."

3.3 PATHWAYS

- A. Pathways (conduit) above recessed ceilings and in nonaccessible locations may be routed exposed.

3.4 CONNECTIONS

- A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
 - 2. Smoke dampers in air ducts of designated HVAC duct systems.
 - 3. Electronically locked doors and access gates.
 - 4. Alarm-initiating connection to elevator recall system and components.
 - 5. Supervisory connections at valve supervisory switches.
 - 6. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 - Identification for Electrical Systems.
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.
- C. Comply with requirements specified in Section 26 0526 - Grounding and Bonding for Electrical Systems.

3.7 OWNER PERSONNEL INSTRUCTION

- A. Provide the following instruction to designated Owner personnel:
 - 1. Hands-On Instruction: On-site, using operational system.
 - 2. Classroom Instruction: Owner furnished classroom, on-site or at other local facility.
 - 3. Factory Instruction: At control unit manufacturer's training facility.

- B. Basic Operation: One-hour sessions for attendant personnel, security officers, and engineering staff; combination of classroom and hands-on:
 - 1. Initial Training: 1 session pre-closeout.
 - 2. Refresher Training: 1 session post-occupancy.
- C. Maintenance Technicians: Detailed training for electrical technicians, on programming, maintaining, repairing, and modifying; factory training:
 - 1. Initial Training: One 3-day session, pre-closeout.
- D. Furnish the services of instructors and teaching aids; have copies of operation and maintenance data available during instruction.
- E. Provide means of evaluation of trainees suitable to type of training given; report results to Owner.

3.8 CLOSEOUT

- A. Closeout Demonstration: Demonstrate proper operation of all functions to Owner.
 - 1. Be prepared to conduct any of the required tests.
 - 2. Have at least one copy of operation and maintenance data, preliminary copy of project record drawings, input/output matrix, and operator instruction chart(s) available during demonstration.
 - 3. Have authorized technical representative of control unit manufacturer present during demonstration.
 - 4. Demonstration may be combined with inspection and testing required by authority having jurisdiction; notify authority having jurisdiction in time to schedule demonstration.
 - 5. Repeat demonstration until successful.
- B. Occupancy of the project will not occur prior to Substantial Completion.
- C. Substantial Completion of the project cannot be achieved until inspection and testing is successful and:
 - 1. Specified diagnostic period without malfunction has been completed.
 - 2. Approved operating and maintenance data has been delivered.
 - 3. Spare parts, extra materials, and tools have been delivered.
 - 4. All aspects of operation have been demonstrated to Owner.
 - 5. Final acceptance of the fire alarm system has been given by authorities having jurisdiction.

6. Occupancy permit has been granted.
 7. Specified pre-closeout instruction is complete.
- D. Perform post-occupancy instruction within 3 months after Substantial Completion.

3.9 MAINTENANCE

- A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- C. Perform routine inspection, testing, and preventive maintenance required by NFPA 72, including:
1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
 2. Repairs required, unless due to improper use, accidents, or negligence beyond the control of the maintenance contractor.
 3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D. Provide trouble call-back service upon notification by Owner:
1. Provide on-site response within 2 hours of notification.
 2. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 3. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E. Provide a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.

- F. Maintain a log at each fire alarm control unit, listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced. Submit duplicate of each log entry to Owner's representative upon completion of site visit.
- G. Comply with Owner's requirements for access to facility and security.
- H. Software Service Agreement
 - 1. Comply with UL 864.
 - 2. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
 - 3. 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.
 - a. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

END OF SECTION

This page intentionally left blank

SECTION 31 1000 - SITE CLEARING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Clearing and protection of vegetation.
- B. Removal of existing debris.

1.2 RELATED REQUIREMENTS

- A. Section 01 1000 - Summary: Limitations on Contractor's use of site and premises.
- B. Section 01 5000 - Temporary Facilities and Controls: Site fences, security, protective barriers, and waste removal.
- C. Section 01 7000 - Execution and Closeout Requirements: Project conditions; protection of bench marks, survey control points, and existing construction to remain; reinstallation of removed products.
- D. Section 02 4100 - Site Demolition: Removal of built elements and utilities.
- E. Section 31 2200 - Grading: Fill material for filling holes, pits, and excavations generated as a result of removal operations.
- F. Section 31 2323 - Fill: Fill material for filling holes, pits, and excavations generated as a result of removal operations.

1.3 QUALITY ASSURANCE

- A. Conform to applicable code for environmental requirements, disposal of debris, burning debris on site, and use of herbicides.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Fill Material: As specified in Section 31 2200 - Grading

PART 3 EXECUTION

3.1 PREPARATION

- A. Call Local Utility Line Information series at number shown on drawings not less than three working days before performing Work
 - 1. Request underground utilities be located and marked within and surrounding construction areas.

3.2 SITE CLEARING

- A. Comply with other requirements specified in Section 01 7000.

- B. Minimize production of dust due to clearing operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

3.3 EXISTING UTILITIES AND BUILT ELEMENTS

- A. Coordinate work with utility companies; notify before starting work and comply with their requirements; obtain required permits.
- B. Protect existing utilities to remain from damage.
- C. Do not disrupt public utilities without permit from authority having jurisdiction.
- D. Protect improvements on adjoining properties as well as those on the Owner's Property.
- E. Restore any improvements damaged by this Work to their original condition, as acceptable to the Owner, other parties, or authorities having jurisdiction.

3.4 VEGETATION

- A. Scope: Remove trees, shrubs, brush, and stumps in areas to be covered by building structure, paving, playing fields, lawns, and planting beds.
- B. Do not begin clearing until vegetation to be relocated has been removed.
- C. Do not remove or damage vegetation beyond the limits indicated on drawings.
 - 1. Trees and shrubs that are to remain within limits of disturbance will be indicated on Drawings or conspicuously marked on site.
 - 2. Unless otherwise noted, trees within the limits of disturbance shall become the property of the Contractor and shall be removed from the site.
- D. Install substantial, highly visible fences at least 3 feet high to prevent inadvertent damage to vegetation to remain:
 - 1. At vegetation removal limits.
 - 2. Around trees to remain within vegetation removal limits; locate no closer to tree than at the drip line.
- E. In areas where vegetation must be removed but no construction will occur other than pervious paving, remove vegetation with minimum disturbance of the subsoil.
- F. Vegetation Removed: Do not burn, bury, landfill, or leave on site, except as indicated.
 - 1. Chip, grind, crush, or shred vegetation for mulching, composting, or other purposes; preference should be given to on-site uses.
 - 2. Trees: Sell if marketable; if not, treat as specified for other vegetation removed; remove stumps and roots to depth of 18 inches.

- 3. Existing Stumps: Treat as specified for other vegetation removed; remove stumps and roots to depth of 18 inches.
- 4. Sod: Re-use on site if possible; otherwise sell if marketable, and if not, treat as specified for other vegetation removed.
- 5. Fill holes left by removal of stumps and roots, using suitable fill material, with top surface neat in appearance and smooth enough not to constitute a hazard to pedestrians.
- G. Remove above -grade improvements such as posts, poles, fences, and other Work as specifically indicated or necessary to permit new construction.
- H. Masonry or other construction material that will result in dust shall be wet down during demolition and removal.
- I. Remove promptly all salvage that become property of the Contractor and is not to be reused in construction. Sale of material on site is prohibited.
- J. Restoration: If vegetation outside removal limits or within specified protective fences is damaged or destroyed due to subsequent construction operations, replace at no cost to Owner.

3.5 DEBRIS

- A. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.
- B. Remove debris, junk, and trash from site.
- C. Remove paving, curbs, and slabs.
- D. Where indicated on Drawings, partially remove paving, curbs, and slabs. Neatly saw cut edges at right angle to surface.
- E. Remove abandoned utilities. Indicated removal termination point for underground utilities on Record Documents.
- F. Do not burn or bury materials on site unless authorized in writing by authority having jurisdiction.
- G. Leave site in clean condition, ready for subsequent work.
- H. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION

This page intentionally left blank

SECTION 31 2200 - GRADING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Removal and storage of topsoil.
- B. Rough grading the site for site structures, building pads, and parking areas.
- C. Replacement of topsoil and finish grading.
- D. Replacement of topsoil and finish grading for planting.

1.2 RELATED REQUIREMENTS

- A. Section 31 1000 - Site Clearing.
- B. Section 31 2316 - Excavation .
- C. Section 31 2316.13 - Trenching: Trenching and backfilling for utilities.
- D. Section 31 2316.26 - Rock Removal.
- E. Section 31 2323 Fill - : Filling and compaction.
- F. Section 32 9219 - Seeding: Finish ground cover.
- G. Section 32 9223 - Sodding: Finish ground cover.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Topsoil: See Section 31 2323.
- B. Other Fill Materials: See Section 31 2323.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench mark and intended elevations for the Work are as indicated.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Stake and flag locations of known utilities.
- C. Locate, identify, and protect from damage above- and below-grade utilities to remain.
- D. Notify utility company to remove and relocate utilities.

- E. Protect site features to remain, including but not limited to bench marks, survey control points, existing structures, fences, sidewalks, paving, curbs, and trees, from damage by grading equipment and vehicular traffic.
- F. Protect trees to remain by providing substantial fencing around entire tree at the outer tips of its branches; no grading is to be performed inside this line.
- G. Protect plants, lawns, rock outcroppings, and other features to remain as a portion of final landscaping.

3.3 ROUGH GRADING

- A. Remove topsoil from areas to be further excavated, re-landscaped, or re-graded, without mixing with foreign materials.
- B. Do not remove topsoil when wet.
- C. Remove subsoil from areas to be further excavated, re-landscaped, or re-graded.
- D. Do not remove wet subsoil, unless it is subsequently processed to obtain optimum moisture content.
- E. When excavating through roots, perform work by hand and cut roots with sharp axe.
- F. See Section 31 2323 for filling procedures.
- G. Benching Slopes: Horizontally bench existing slopes greater than 3:1 to key fill material to slope for firm bearing.
- H. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill.

3.4 SOIL REMOVAL AND STOCKPILING

- A. Stockpile topsoil to be re-used on site; remove remainder from site.
- B. Stockpile subsoil to be re-used on site; remove remainder from site.
- C. Stockpiles: Use areas designated on site; pile depth not to exceed 8 feet; protect from erosion.

3.5 FINISH GRADING

- A. Before Finish Grading:
 - 1. Verify building and trench backfilling have been inspected.
 - 2. Verify subgrade has been contoured and compacted.
- B. Remove debris, roots, branches, stones, in excess of 2 inch in size. Remove soil contaminated with petroleum products.
- C. Where topsoil is to be placed, scarify surface to depth of 6 inches.

- D. In areas where vehicles or equipment have compacted soil, scarify surface to depth of 6 inches.
- E. Place topsoil in areas where seeding, sodding, and planting are required.
- F. Place topsoil to the following compacted thicknesses:
 - 1. Areas to be Seeded with Grass: 6 inches.
 - 2. Areas to be Sodded: 4 inches.
 - 3. Shrub Beds: 18 inches.
 - 4. Flower Beds: 12 inches.
 - 5. Planter Boxes: To within 3 inches of box rim.
- G. Place topsoil during dry weather.
- H. Remove roots, weeds, rocks, and foreign material while spreading.
- I. Near plants, buildings, and pavement, spread topsoil manually to prevent damage.
- J. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.
- K. Lightly compact placed topsoil.

3.6 TOLERANCES

- A. Top Surface of Subgrade: Plus or minus 0.10 foot (1-3/16 inches) from required elevation.
- B. Top Surface of Finish Grade: Plus or minus 0.04 foot (1/2 inch).

3.7 REPAIR AND RESTORATION

- A. Existing Facilities, Utilities, and Site Features to Remain: If damaged due to this work, repair or replace to original condition.
- B. Trees to Remain: If damaged due to this work, trim broken branches and repair bark wounds; if root damage has occurred, obtain instructions from Architect/Engineer as to remedy.
- C. Other Existing Vegetation to Remain: If damaged due to this work, replace with vegetation of equivalent species and size.

3.8 FIELD QUALITY CONTROL

- A. See Section 31 2323 for compaction density testing.

3.9 CLEANING

- A. Remove unused stockpiled topsoil and subsoil. Grade stockpile area to prevent standing water.

- B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION

SECTION 31 2316 - EXCAVATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Excavating for building volume below grade, footings, pile caps, slabs-on-grade, paving, site structures, utilities within the building, utilities, and site development.

1.2 RELATED REQUIREMENTS

- A. Document 22160136.000 prepared by Schnabel Engineering: Geotechnical Engineering Report; bore hole locations and findings of subsurface materials.
- B. Section 01 7000 - Execution and Closeout Requirements: General requirements for dewatering of excavations and water control.
- C. Section 02 4100 -Site Demolition: Shoring and underpinning.
- D. Section 31 1000 - Site Clearing.
- E. Section 31 2200 - Grading: Grading.
- F. Section 31 2316.13 - Trenching: Excavating for utility trenches outside the building to utility main connections.
- G. Section 312316.26 - Rock Removal: Removal of rock during excavating.
- H. Section 31 2323 - Fill: Fill materials, filling, and compacting.

1.3 PRICE AND PAYMENT PROCEDURES

- A. See Section 01 2200 - Unit Prices, for general requirements applicable to unit prices for unsatisfactory soil materials.
- B. Excavating Soil Materials:
 - 1. Measurement method: Based upon a lump sum price for earthwork.
 - 2. Includes: Excavating to required elevations, loading and placing materials in fill areas.
 - 3. Does Not Include Over-Excavation: Payment will not be made for over-excavated work nor for replacement materials.
- C. See Section 01 2000 - Price and Payment Procedures, for general requirements applicable to lump sum prices for excavation.
- D. See Section 31 2316.26 - Rock Removal, for measurement and payment provisions related to rock removal.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

- B. Dewatering Plan: Describe dewatering methods to be used to keep excavations dry, if required.

1.5 PROJECT CONDITIONS

- A. Verify that survey bench mark and intended elevations for the Work are as indicated.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench mark and intended elevations for the work are as indicated.

3.2 PREPARATION

- A. Call Local Utility Line Information service at number shown on Drawings not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum locations.
- C. See Section 31 2200 for additional requirements.
- D. Locate, identify, and protect utilities that remain from damage.
- E. Notify utility company to remove and relocate utilities.
- F. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, curbs, and lawns from excavating equipment and vehicular traffic.

3.3 EXCAVATING

- A. All excavation shall be unclassified regardless of material encountered.
- B. Underpin adjacent structures that could be damaged by excavating work.
- C. Excavate to accommodate building foundations, slabs-on-grade, paving, site structures, and construction operations.
- D. Notify Architect/Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- E. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.
- F. Do not interfere with 45 degree bearing splay of foundations.
- G. Cut utility trenches wide enough to allow inspection of installed utilities.
- H. Hand trim excavations. Remove loose matter.

- I. Remove lumped subsoil, boulders, and rock up to 1/3 cu yd measured by volume. See Section 31 2316.26 for removal of larger material.
- J. Correct areas that are over-excavated and load-bearing surfaces that are disturbed; see Section 31 2323.
- K. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- L. Remove excavated material that is unsuitable for re-use from site.
- M. Stockpile excavated material to be re-used in area designated on site in accordance with Section 31 2200.
- N. Remove excess excavated material from site.
- O. Repair or replace items indicated to remain that are damaged by excavation.
- P. Excavate subsoil from areas to be further excavated, re-landscaped, or regraded.
- Q. Do not excavate wet subsoil or excavate and process wet material to obtain optimum moisture content.
- R. Benching Slopes: Horizontally bench existing slopes greater than 3:1 to key placed fill material into slope to provide firm bearing.
- S. Stability: Replace damaged or displaced subsoil as specified for fill.
- T. Where unauthorized excavations have been carried below or beyond points required, restore these areas to the elevations and dimensions shown on the Drawings with material approved by Engineer and compact as specified. This Work shall be performed at no additional cost to the Owner.
- U. Excavate unsatisfactory soil materials encountered that extend below required elevations to the additional depth as directed by Engineer. See Specification Section 31 2323 - Fill for classification of unsatisfactory soil materials. -
 - 1. Where removal of unsatisfactory material is due to fault or negligence of the Contractor, by inadequate shoring or bracing, dewatering, material storage or other failure to meet specified requirements, Work shall be performed at no additional cost to the Owner.
- V. Areas that receive seeding shall be graded below finished grades shown, leaving space for topsoiling.
- W. Stockpile excavated soil material satisfactory for backfill or fill until required. Place, grade, and shape stockpiles for proper drainage.
- X. Cut slopes shall be shaped and cleaned of loose rock as the work progresses in accordance with the following sequence:
 - 1. Slopes whose vertical height is less than 5 feet shall be shaped, cleaned, and seeded (where required) in one operation.

3.4 EXCAVATION (FOR STRUCTURES)

- A. Conform to elevations and dimensions shown on the drawings. Extend excavation sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, and for other construction required. Foundation concrete shall not be placed until the bearing stratum has been examined and found satisfactory for the design bearing capacity.
- B. Where rock is encountered, notify Engineer. When the entire structure will bear on rock, it shall be used to support the foundation. Where only a part of the foundation will bear on rock, excavate 8 inches below subgrade of floor or footings and backfill with aggregate fill and thoroughly compact.

3.5 SURFACE WATER CONTROL

- A. Control and remove unanticipated water seepage into excavation.
- B. Provide ditches, berms, and other devices to divert and drain surface water from excavation area.
- C. Divert surface water and seepage water within excavation areas into sumps or settling basins prior to pumping water into drainage channels and storm drains.

3.6 DEWATERING

- A. Design and provide dewatering system to permit Work to be completed on dry and stable subgrade.
- B. Operate dewatering system continuously until backfill is minimum 2 feet above normal ground water table elevation.
- C. When dewatering system cannot control water within excavation, notify Engineer and stop excavation work.
 - 1. Supplement or modify dewatering system and provide other remedial measures to control water within excavation.
 - 2. Demonstrate dewatering system operation complies with performance requirements before resuming excavation operations.
- D. Modify dewatering systems when operation causes or threatens to cause damage to new construction, existing site improvements, adjacent property, or adjacent water wells.
- E. Discharge groundwater and seepage water within excavation areas into sumps or settling basins prior to pumping water into drainage channels and storm drains.
- F. Remove dewatering and surface water control systems after dewatering operations are discontinued.

3.7 PROOFROLLING

- A. Proofroll areas to receive fill, pavement, and building slabs to identify areas of soft yielding soils.
 - 1. Use loaded tandem-axle pneumatic tired dump truck or large smooth drum roller.
 - 2. Load equipment to maximum 50 tons gross weight and make a minimum of 4 passes with 2 passes perpendicular to the others.
- B. Undercut such areas to firm soil, backfill with granular fill, and compact to density equal or greater than requirements for subsequent fill material.
- C. Do not proofroll or undercut until soil has been dewatered.

3.8 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Provide for visual inspection of load-bearing excavated surfaces before placement of foundations.

3.9 PROTECTION

- A. Prevent displacement of banks and keep loose soil from falling into excavation; maintain soil stability.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- C. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth operations.

END OF SECTION

This page intentionally left blank

SECTION 31 2316.13 - TRENCHING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Backfilling and compacting for utilities outside the building.

1.2 RELATED REQUIREMENTS

- A. Document 22160136.000 prepared by Schnabel Engineering: Geotechnical Engineering Report; bore hole locations and findings of subsurface materials.
- B. Section 31 2200 - Grading: Site grading.
- C. Section 31 2316 - Excavation: Building and foundation excavating.
- D. Section 31 2316.26 - Rock Removal: Removal of rock during excavating.
- E. Section 31 2323 - Fill: Backfilling at building and foundations.

1.3 DEFINITIONS

- A. Utility: Any buried pipe, duct, conduit, or cable.
- B. Utility Structures: Manholes, catch basins, inlets, valve vaults, hand holes, and other utility access structures as indicated on Drawings.
- C. Trench Terminology:
 - 1. Trench Bottom: Area under bottom of trench supporting bedding.
 - 2. Bedding: Fill placed under utility pipe to 1/6 pipe diameter.
 - 3. Initial Backfill: Fill placed from 1/6 of outside pipe diameter to 12 inches above top of pipe.
 - 4. Final Backfill: Fill placed from initial backfill to subgrade

1.4 REFERENCES

- A. AASHTO T 180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop 2022, with Errata .
- B. AASHTO T 99 - Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop 2015.
- C. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates 2019.
- D. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method 2015, with Editorial Revision (2016).

- E. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)) 2012 (Reapproved 2021).
- F. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method 2015.
- G. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) 2023.
- H. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) 2017, with Editorial Revision (2020).
- I. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils 2017, with Editorial Revision (2018).
- J. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)) 2012 (Reapproved 2021).
- K. VDOT Road and Bridge Standards - Virginia Department of Transportation Road and Bridge Standards 2016.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan. Prepare Excavation Protection Plan under direct supervision of Professional Engineer experienced in design of this Work and licensed in the State of Virginia.
- C. Dewatering Plan: If required, describe methods of dewatering and disposal of water.
- D. Materials Sources: Submit name of imported materials source.
- E. Compaction Density Test Reports.

1.6 FIELD MEASUREMENTS

- A. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or side dimensions, without specific approval of Engineer. Unauthorized excavation shall be replaced at Contractor's expense.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. When necessary, store materials on site in advance of need.
- B. When fill materials need to be stored on site, locate stockpiles where directed by the Engineer.
 - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
 - 2. Prevent contamination.

3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.1 FILL MATERIALS

- A. Aggregate fill shall meet VDOT requirements for No. 25 or No. 26 crusher run aggregate or No. 57 coarse aggregate.
- B. Clean earth fill shall be free of debris, roots, frozen materials, organic matter, rock or gravel larger than 1 inch in any dimension or other harmful matter.
- C. Native fill shall be 95 percent free of stones larger than 4 inches in any dimension or other harmful matter.
- D. Bedding Material: From trench bottom to 1/6 of outside pipe diameter.
 1. Pipe: Clean earth fill or aggregate fill.
 2. PVC Pipe: Aggregate fill.
- E. Bedding for Structures: Aggregate fill.
- F. Initial Backfill: From 1/6 of outside pipe diameter to 12 inches minimum above pipe.
 1. Pipe: Clean earth fill or aggregate fill.
 2. PVC Pipe: Aggregate fill.
- G. Final Backfill to Subgrade:
 1. Under Traveled Rights-of-Way: Aggregate fill.
 2. Under Landscape, Road Shoulders, and Existing or Future Paved Areas: Native fill or aggregate fill.

2.2 ACCESSORIES

- A. Concrete: Class A3 concrete conforming to VDOT Road and Bridge Standards.
 1. Compressive strength of 3,000 psi at 28 days.
 2. Air entrained, content of 6% (plus or minus 2%).
 3. Water cement ratio of 0.49.
 4. Slump of 1-5 inches.
 5. Minimum cement content of 588 lbs. per cubic yard.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench marks and intended elevations for the work are as indicated.

3.2 PREPARATION

- A. Call Local Utility Line Information service at number shown on Drawings not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum locations.
- C. See Section 31 2200 for additional requirements.
- D. Locate, identify, and protect utilities that remain and protect from damage.
- E. Notify utility company to remove and relocate utilities.
- F. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, curbs, and pavement from excavating equipment and vehicular traffic.
- G. Protect plants, lawns, rock outcroppings, and other features to remain.

3.3 TRENCHING

- A. Excavate subsoil required for utilities.
- B. Notify Architect/Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- C. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.
- D. Do not interfere with 45 degree bearing splay of foundations.
- E. Cut trenches wide enough to allow inspection of installed utilities.
- F. Hand trim excavations. Remove loose matter.
- G. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.
- H. Remove lumped subsoil, boulders, and rock up to 1/3 cu yd measured by volume. See Section 31 2316.26 for removal of larger material.
- I. Remove excavated material that is unsuitable for re-use from site.
- J. Stockpile excavated material to be re-used in area designated on site in accordance with Section 31 2200.
- K. Remove excess excavated material from site.
- L. Trench Width: Excavate bottom of trenches in accordance with the following schedule or as indicated on Drawings:

1. 0 - 6' Trench Depth: Outside diameter of pipe bell, plus 12 inches.
 2. Greater than 6' Trench Depth: Outside diameter of pipe bell, plus 12 inches, plus 2 inches of width per foot for each foot of depth greater than 6 feet.
- M. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and pipe.
- N. Maintain vertical faces to an elevation equal to 12 inches above top of pipe.
1. When Project conditions permit, side walls may be sloped or benched above this elevation.
 2. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this Section.
- O. Support Utilities and Structures:
1. Keep trench width at top of trench to practical minimum to protect adjacent or crossing utility lines.
 2. Support utilities crossing trench by means acceptable to utility company.
 3. Do not interfere with 45-degree bearing splay of foundations.
 4. Provide temporary support for structures above and below ground.
- P. When subsurface materials at bottom of trench are loose or soft, excavate to firm subgrade or to depth directed by Engineer.
1. Cut out soft areas of subgrade not capable of compaction in place.
 2. Backfill with aggregate fill and compact to density equal to or greater than requirements of subsequent backfill material.
- Q. When rock is encountered, excavate rock encountered 6 inches below the pipe for pipe bedding.
- R. Where rock is encountered so that a manhole, vault, or other structure will bear on rock, it shall be used to support the foundation. Where only a part of the foundation will bear on rock, at least 8 inches of compacted granular material shall be provided below bottom of footings.
- S. Trim excavation. Hand trim for bell and spigot pipe joints where required. Shape trench bottom to afford circumferential support to the lower fourth of the pipe or excavate 6 inches below bottom of pipe for pipe bedding. Remove loose matter.
- T. Excavate trench bottom for PVC pipe to a depth 3 inches below the pipe and backfill overdepth with aggregate fill.
- U. Correct over excavated areas with compacted backfill as specified for authorized excavation or replace with flowable fill as directed by Engineer.

- V. All excavating in stream channels shall be performed in accordance with all applicable permits for the project.

3.4 SHEETING AND SHORING

- A. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.
- B. Support trenches more than 5 feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.
- C. Design sheeting and shoring to be removed at completion of excavation work.
- D. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.
- E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.5 SURFACE WATER CONTROL

- A. Control and remove unanticipated water seepage into excavation.
- B. Provide ditches, berms, and other devices to divert and drain surface water from excavation area.
- C. Divert surface water and seepage water within excavation areas into sumps or settling basins prior to pumping water into drainage channels and storm drains.

3.6 DEWATERING

- A. Design and provide dewatering system to permit Work to be completed on dry and stable subgrade.
- B. Operate dewatering system continuously until backfill is minimum 2 feet above normal ground water table elevation.
- C. When dewatering system cannot control water within excavation, notify Engineer and stop excavation work.
 - 1. Supplement or modify dewatering system and provide other remedial measures to control water within excavation.
 - 2. Demonstrate dewatering system operation complies with performance requirements before resuming excavation operations.
- D. Modify dewatering systems when operation causes or threatens to cause damage to new construction, existing site improvements, adjacent property, or adjacent water wells.
- E. Discharge ground water and seepage water within excavation areas into sumps or settling basins prior to pumping water into drainage channels and storm drains.

- F. Remove dewatering and surface water control systems after dewatering operations are discontinued.

3.7 BEDDING, HAUNCHING, AND INITIAL BACKFILL

- A. Place bedding full width of trench to the depth indicated on Drawings and compact by tamping or rodding to prevent settlement. Perform in accordance with schedule at end of this Section.
- B. Install utility pipe and conduit in accordance with the respective utility section.
- C. Support pipe uniformly along entire length of pipe.
- D. Carefully place initial backfill to 12 inches above top of pipe or to depth indicated on Drawings. Compact in accordance with schedule at end of this Section.
- E. Backfill shall be placed by hand, uniformly on each side of the pipe and compacted in layers not exceeding 6 inches.

3.8 FINAL BACKFILLING TO SUBGRADE

- A. Backfill to contours and elevations indicated using unfrozen materials.
- B. Fill up to finish grade elevations unless otherwise indicated.
- C. Employ a placement method that does not disturb or damage other work.
- D. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- E. Maintain optimum moisture content of fill materials to attain required compaction density.
- F. Place fill material in continuous layers and compact in accordance with schedule at end of this section.
- G. Layers shall not exceed 12 inches. Under road shoulders and under existing or future paved areas, layers shall not exceed 8 inches.
- H. Employ compaction equipment suitable for materials to be compacted and work area locations. Use power driven hand tampers for compacting materials adjacent to structures.
- I. Replace topsoil to at least original depth in areas to be seeded.

3.9 DISPOSAL OF EXCESS OR UNSATISFACTORY MATERIALS

- A. Dispose of excess or unsatisfactory material offsite and legally.
- B. Furnish Engineer with certificate of disposal site or agreement from private property owner.

3.10 TOLERANCES

- A. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.11 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Perform laboratory material tests in accordance with ASTM D1557 or AASHTO T 180.
- C. Perform in place compaction tests in accordance with the following:
 - 1. Density Tests: ASTM D1556/D1556M, ASTM D2167, ASTM D6938, or ASTM D698 (AASHTO T 99).
 - 2. Moisture Tests: ASTM D6938.
- D. Frequency of Tests: One test per lift for every 1,000 feet of trench.
- E. Contractor shall employ an independent testing firm to assure compliance with these specifications for materials and compaction.
- F. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

3.12 PROTECTION OF FINISHED WORK

- A. Section 01 7000 - Execution and Closeout Requirements: Protecting finished Work.
- B. Reshape and re-compact fills subjected to vehicular traffic during construction.

3.13 CLEANING

- A. Leave unused materials in a neat, compact stockpile.
- B. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

3.14 SCHEDULE OF COMPACTION

- A. Compact each layer of fill or backfill to not less than the following percentages of the maximum density at optimum moisture content as determined by ASTM D698 (AASHTO T 99):
 - 1. 95 percent beneath and within 25 feet of buildings and structures, including those shown for future construction.
 - 2. 95 percent beneath pavements, walks, and road shoulders, including those shown for future construction.
 - 3. 90 percent in other unpaved areas.
 - 4. Minimum compaction in any area shall be to the density of the adjacent soil.

END OF SECTION

This page intentionally left blank

SECTION 31 2316.26 - ROCK REMOVAL

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Removal of identified and discovered rock during excavation.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 31 2316.13 - Trenching.
- C. Section 31 2323 - Fill: Fill materials.

1.3 PRICE AND PAYMENT PROCEDURES

- A. See Section 01 2200 - Unit Prices, for additional unit price requirements.
- B. Site Rock Removal:
 - 1. Basis of Measurement: By the cubic yard measured before disintegration. Includes preparation of rock for removal, mechanical disintegration of rock, removal from position, loading and removing from site. For over excavation, payment will not be made for over excavated work nor for replacement materials.
- C. Trench Rock Removal:
 - 1. Basis of Measurement: By the cubic yard measured before disintegration. Includes preparation of rock for removal, mechanical disintegration of rock, removal from position, loading and removing from site. For over excavation, payment will not be made for over excavated work nor for replacement materials.

1.4 DEFINITIONS

- A. Site Rock: Solid mineral material with a volume in excess of 1/3 cubic yard or solid material that cannot be removed with a 3/4 cubic yard capacity excavator without drilling or blasting.
- B. Trench Rock: Solid mineral material with a volume in excess of 1/6 cubic yard or solid material that cannot be removed with a 3/4 cubic yard capacity excavator without drilling or blasting.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

1.6 SCHEDULING

- A. Section 01 3000 - Administrative Requirements: Coordination and project conditions.
- B. Schedule Work to avoid disruption to occupied buildings nearby.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Mechanical Disintegration Compound: Grout mix of materials that expand on curing.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify site conditions and note subsurface irregularities affecting Work of this Section.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum.

3.3 ROCK REMOVAL

- A. Excavate and remove rock by mechanical methods only; use of explosives is prohibited.
- B. Mechanical Methods: Drill holes and utilize expansive tools to fracture rock.
- C. If rock is uncovered requiring the explosives method for rock disintegration, notify the Architect/Engineer.
- D. Form level bearing at bottom of excavations.
- E. Remove shale layers to provide sound and unshattered base for footings and foundations.
- F. In utility trenches, excavate to 6 inches below invert elevation of pipe and 24 inches wider than pipe diameter.
- G. Remove excavated materials from site.
- H. Correct unauthorized rock removal to directions of Architect/Engineer.

3.4 FIELD QUALITY CONTROL

- A. Independent agency field inspection will be provided under provisions of Section 01 4000 - Quality Requirements.
- B. Request visual inspection of foundation bearing surfaces by Engineer before installing subsequent work.

END OF SECTION

SECTION 31 2323 - FILL

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Filling, backfilling, and compacting for footings, slabs-on-grade, paving, site structures, and utilities.
- B. Filling holes, pits, and excavations generated as a result of removal (demolition) operations.

1.2 RELATED REQUIREMENTS

- A. Document 22160136.000 prepared by Schnabel Engineering: Geotechnical Engineering Report; bore hole locations and findings of subsurface materials.
- B. Section 03 3000 - Cast-in-Place Concrete.
- C. Section 31 2200 - Grading: Preparation, soil removal, site grading.
- D. Section 31 2316 - Excavation: Removal and handling of soil to be re-used.
- E. Section 31 2316.13 - Trenching: Excavating for utility trenches outside the building to utility main connections.
- F. Section 31 2316.16 - Rock Removal: Removal of rock during excavating.

1.3 PRICE AND PAYMENT PROCEDURES

- A. Native General Fill:
 - 1. Basis of Measurement: Shall not be measured or paid for as a separate pay item. The cost thereof shall be included in the lump sum price for earthwork.
- B. Structural Fill:
 - 1. Basis of Measurement: Shall not be measured or paid for as a separate pay item. The cost thereof shall be included in the lump sum price for earthwork.
- C. Aggregate Fill:
 - 1. Basis of Measurement: Shall not be measured or paid for as a separate pay item. The cost thereof shall be included in the lump sum price for earthwork.
- D. Filtering Material:
 - 1. Basis of Measurement: Shall not be measured or paid for as a separate pay item. The cost thereof shall be included in the lump sum price for earthwork.

1.4 REFERENCE STANDARDS

- A. AASHTO T 180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop 2022, with Errata .

- B. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates 2019.
- C. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method 2015, with Editorial Revision (2016).
- D. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)) 2012 (Reapproved 2021).
- E. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method 2015.
- F. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) 2017, with Editorial Revision (2020).
- G. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils 2017, with Editorial Revision (2018).
- H. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) 2023.
- I. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)) 2012 (Reapproved 2021).
- J. VDOT Road and Bridge Standards - Virginia Department of Transportation Road and Bridge Standards 2016.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Materials Sources: Submit name of imported materials source.
- C. Compaction Density Test Reports.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. When necessary, store materials on site in advance of need.
- B. When fill materials need to be stored on site, locate stockpiles where agreed upon by Owner, Contractor, and Engineer.
 - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
 - 2. Prevent contamination.
 - 3. Protect stockpiles from erosion and deterioration of materials.

1.7 COMPACTION TESTING

- A. Owner will provide compaction testing.

1.8 EXCAVATION

- A. See Section 31 2316 for excavation.

PART 2 PRODUCTS

2.1 FILL MATERIALS

- A. Aggregate fill shall meet VDOT requirements for No. 57 coarse aggregate.
- B. Filtering material shall be a graded mixture of natural or crushed gravel, crushed stone, or natural sand with 100 percent passing a 1/2-inch sieve and none passing a No. 50 sieve, ASTM D448, Size No. 8.
- C. Structural fill material is any materials classified by ASTM D2487 as GW, GP, GM, GC, SW, SP, SM, SC, CL, or ML, free of debris, roots, wood, scrap material, vegetation, organic matter, refuse, soft unsound particles, and frozen, deleterious, or objectionable materials. Unless specified otherwise, the maximum particle diameter shall not exceed 21 inches in any dimension nor exceed one-half the lift thickness at the intended location.
- D. Unsatisfactory soil materials which do not comply with the requirements for structural fill materials. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as structural fill material which contains root and other organic matter, frozen material, and stones larger than 2 inches.
- E. Rock fill: Rock fill shall consist predominately of durable rock fragments, shot rock, or other angular stone, free of organic materials, weathered shales, clay soil, or other deleterious materials. Rock fill material shall have no rock fragments over two feet (2') in greatest dimension. Shale shall not be used in rock fill without the written permission of the Engineer.
- F. Weathered shale fill: Weathered shale fill shall consist of weathered shale and soft rock, free of organic materials, clay soil, or other deleterious materials. Weathered shale fill material shall have no rock fragments over six inches (6") in greatest dimension.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench marks and intended elevations for the Work are as indicated.
- B. See Section 31 2200 for additional requirements.
- C. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.
- D. Verify structural ability of unsupported walls to support imposed loads by the fill.

3.2 PREPARATION

- A. See Section 31 2200 - Grading or Section 31 2316.13 - Trenching, as applicable.
- B. Scarify subgrade surface to a depth of 6 inches to identify soft spots.

- C. Cut out soft areas of subgrade not capable of compaction in place. Backfill with structural fill.
- D. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- E. Until ready to fill, maintain excavations and prevent loose soil from falling into excavation.
- F. Proofroll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

3.3 FILLING

- A. Fill to contours and elevations indicated using unfrozen materials.
- B. Fill up to finish grade elevations unless otherwise indicated.
- C. Employ a placement method that does not disturb or damage other work.
- D. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- E. Maintain optimum moisture content of fill materials to attain required compaction density.
- F. Obtain fill from excavation or other approved sources. The material shall be such that it can be compacted in accordance with these specifications. Maximum rock size shall be 75 percent of compacted layer thickness or maximum of 6 inches diameter. Prevent nesting of large rocks and compact fill to prevent voids. Maximum rock size within 12 inches of footing elevations shall be 2-inch diameter.
- G. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified percentage of maximum density.
- H. Fill material that has been removed as too wet to permit compaction may be stockpiled or spread to dry. When moisture content is reduced to a satisfactory value, the material may be used as fill or backfill.
- I. Place fill to obtain elevations shown on the Drawings. Do not place fill on muddy or frozen areas.
- J. Excavate depressions caused by removal of stumps or other clearing operations to firm subgrade, fill with clean earth fill, and compact as specified.
- K. When the existing ground surface has been disturbed and has a density of less than that specified for the particular area classification, scarify the ground surface, pulverize, adjust moisture condition to optimum moisture content, and compact to required depth and percentage of maximum density.
- L. Backfill footing drains as shown on Drawings.
- M. Place backfill and fill materials evenly adjacent to structures. Prevent wedging action of the backfill against structures by carrying the material uniformly around the structure to

approximately the same elevation in each lift.

- N. Place aggregate fill material under all building slabs on grade. Compact to density required for fill under buildings.
- O. Place fill material in continuous layers and compact in accordance with schedule at end of this Section.
- P. Backfill against supported foundation walls. Do not backfill against unsupported foundation walls.
- Q. Backfill simultaneously on each side of unsupported foundation walls until supports are in place.
- R. Slope grade away from building minimum 2 percent slope for minimum distance of 10 ft., unless noted otherwise.
- S. Make gradual grade changes. Blend slope into level areas.
- T. Remove surplus backfill materials from site.
- U. Leave fill material stockpile areas free of excess fill materials.
- V. Reshape and re-compact fills subjected to vehicular traffic.

3.4 COMPACTION

- A. Compact soil materials using equipment suitable for materials to be compacted and work area locations. Use power-driven hand tampers for compacting materials adjacent to structures.
- B. Provide equipment capable of adding moisture to the soil material as determined by moisture-density tests.
- C. Where required, uniformly apply water to the surface of subgrade or layer of soil material in such manner as to prevent free water appearing on the surface, either during or subsequent to compaction operations.

3.5 TOLERANCES

- A. Top Surface of General Filling: Plus or minus 1 inch from required elevations.

3.6 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Perform laboratory material tests in accordance with ASTM D1557, ASTM D698, or AASHTO T 180.
- C. Perform in place compaction tests in accordance with the following:
 - 1. Density Tests: ASTM D1556/D1556M, ASTM D2167, or ASTM D6938.

- 2. Moisture Tests: ASTM D6938.
- D. If tests indicate Work does not meet specified requirements, remove Work, replace and retest.
- E. Frequency of Tests: Tests shall be performed on each lift of fill placed at the rates of one (1) test per 10,000 square feet of fill area, but not less than two (2) sets per lift, regardless of size of fill.

3.7 PROTECTION OF FINISHED WORK

- A. Section 01 7000 - Execution and Closeout Requirements: Protecting finished Work.
- B. Reshape and re-compact fills subjected to vehicular traffic and erosion.
- C. Where compacted areas are disturbed by subsequent construction or adverse weather, scarify the surface, reshape, and compact to the required density. Use hand tamper for recompaction over underground utilities and underfloor subdrains.
- D. Protect graded areas from the action of the elements. Settlement or other damage that occurs prior to acceptance of the Work shall be repaired and grades satisfactorily re-established.
- E. Repair after cleanup. Upon completion of construction work and after spoil and debris have been removed, regrade any areas disturbed by the operations.

3.8 CLEANING

- A. Leave unused materials in a neat, compact stockpile.
- B. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

3.9 SCHEDULE

- A. Fill Beneath and Within 25 Feet of Buildings and Structures, Including Those Shown for Future Construction
 - 1. Place structural fill and aggregate fill in layers not more than 8 inches in loose depth.
 - 2. Compact to minimum 95 percent of maximum density at optimum moisture content.
- B. Fill Beneath Pavements, Walk, and Road Shoulders, Including Those Shown for Future Construction:
 - 1. Place structural fill and aggregate fill in layers not more than 8 inches in loose depth.
 - 2. Compact to minimum 95 percent of maximum density at optimum moisture content.
- C. Fill Beneath Other Unpaved Areas:

1. Place structural fill and aggregate fill in layers not more than 8 inches in loose depth.
2. Compact to minimum 90 percent of maximum density at optimum moisture content.

END OF SECTION

This page intentionally left blank

SECTION 32 1123 - AGGREGATE BASE COURSES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Aggregate base course.
- B. Paving aggregates.

1.2 RELATED REQUIREMENTS

- A. Section 312200 - Grading: Preparation of site for base course.
- B. Section 312316.13 - Trenching: Compacted fill over utility trenches under base course.
- C. Section 312323 - Fill: Topsoil fill at areas adjacent to aggregate base course; compacted fill under base course.
- D. Section 321216 - Asphalt Paving: Binder and finish asphalt courses.
- E. Section 330513 - Manholes and Structures including frames.

1.3 REFERENCE STANDARDS

- A. AASHTO M 147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses 2017.
- B. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18 in.) Drop 2018.
- C. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates 2019.
- D. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method 2015, with Editorial Revision (2016).
- E. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) 2017, with Editorial Revision.
- F. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)) 2012, with Editorial Revision (2015).
- G. VDOT Road and Bridge Standards - Virginia Department of Transportation Road and Bridge Standards; 2016.
- H. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN m/m³)) 2012, with Editorial Revision (2015).
- I. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method 2015.

- J. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils 2017, with Editorial Revision (2018).
- K. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) 2017a.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Materials Sources: Submit name of imported materials source.
- C. Compaction Density Test Reports.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. When necessary, store materials on site in advance of need.
- B. When aggregate materials need to be stored on site, locate where directed by Owner.
- C. Aggregate Storage, General:
 - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
 - 2. Prevent contamination.
 - 3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Subbase and Aggregate Base Material: Coarse aggregate type as indicated on Drawings conforming to Section 208 of the VDOT Road and Bridge Specifications.
- B. Coarse Aggregate: Coarse aggregate type as indicated on Drawings conforming to Section 203 of the VDOT Road and Bridge Specifications.
- C. Crusher Run Aggregate: Crusher run aggregate type as indicated on Drawings conforming to Section 205 of the VDOT Road and Bridge Specifications.

2.2 SOURCE QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for general requirements for testing and analysis of aggregate materials.
- B. Where aggregate materials are specified using ASTM D2487 classification, test and analyze samples for compliance before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.

- D. Provide materials of each type from same source throughout the Work.
- E. Use sources approved by VDOT.
- F. Perform Work in accordance with VDOT Road and Bridge Specifications; maintain one copy of document on site.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench marks and intended elevations for the work are as indicated.
- B. Verify substrate has been inspected, gradients and elevations are correct, and is dry.

3.2 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- B. Do not place aggregate on soft, muddy, or frozen surfaces.

3.3 INSTALLATION

- A. Place aggregate in minimum 3-inch and maximum 6-inch layers and roller compact to specified density. When total thickness is 6 inches or less, place in one layer. When total thickness is greater than 6 inches, place in two equal layers.
- B. Have each layer of material compacted and approved prior to placing succeeding layers.
- C. Level and contour surfaces to elevations and gradients indicated on Drawings.
- D. Add small quantities of fine aggregate to coarse aggregate when required to assist compaction.
- E. Maintain optimum moisture content of fill materials to attain required compaction density.
- F. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 TOLERANCES

- A. Flatness: Maximum variation of 1/2-inch measured with 10 foot straight edge.
- B. Scheduled Compacted Thickness: Within 1/2-inch.
- C. Variation From Design Elevation: Within 1/2-inch.

3.5 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for general requirements for field inspection and testing.

- B. Perform compaction density testing on compacted aggregate base course in accordance with ASTM D1556.
- C. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D698 ("Standard Proctor").
- D. If tests indicate work does not meet specified requirements, remove work, replace and retest.
- E. Frequency of Tests: Two tests per layer for every 2,000 square feet.
- F. Proof roll compacted aggregate at surfaces that will be under slabs-on-grade, pavers, paving, and sidewalks.

3.6 CLEANING

- A. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- B. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION

SECTION 32 1216 - ASPHALT PAVING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Aggregate base course.
- B. Single course bituminous concrete paving.
- C. Double course bituminous concrete paving.
- D. Surface sealer.

1.2 RELATED REQUIREMENTS

- A. Section 31 2200 - Grading: Preparation of site for paving and base.
- B. Section 31 2323 - Fill: Compacted subgrade for paving.
- C. Section 32 1123 - Aggregate Base Courses: Aggregate base course.
- D. Section 32 1723.13 - Painted Pavement Markings: Pavement markings.
- E. Section 33 0513 - Manholes and Structures: Manholes, including frames; gutter drainage grilles, covers, and frames for placement by this section.

1.3 REFERENCE STANDARDS

- A. AI MS-2 - Asphalt Mix Design Methods 2015.
- B. AI MS-19 - Basic Asphalt Emulsion Manual 2008.
- C. ASTM D946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction 2009a.
- D. VDOT Road and Bridge Specifications 2020 - Road and Bridge Specifications 2020.
- E. VDOT Road and Bridge Standards - Virginia Department of Transportation Road and Bridge Standards 2016.

1.4 SUBMITTALS

- A. Product Data:
 - 1. Submit product information for asphalt and aggregate materials.
 - 2. Submit mix design with laboratory test results supporting design.
- B. Manufacturer's Certification: Certify products are produced at a plant approved by VDOT and meet or exceed specified requirements.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with Section 315 of the VDOT Road and Bridge Specifications.
- B. Maintain one copy of document on site.
- C. Obtain materials from the same source throughout.
- D. Use sources and mixing plant approved by VDOT.

1.6 FIELD CONDITIONS

- A. Do not place asphalt base course or intermediate course when ambient air or road surface temperature is less than 40 degrees F for Mix Designation A; 50 degrees F for Mix Designations D, E, M, and S; or if surface is wet or frozen.
- B. Do not place asphalt surface course when ambient air or base surface temperature is less than 40 degrees F for Mix Designation A; 50 degrees F for Mix Designations D, E, M, and S; or if surface is wet or frozen.
- C. Place bitumen mixture when temperature is not more than 15 degrees F less than initial mixing temperature and not more than maximum specified temperature.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Asphalt Concrete Materials: Conform to Section 211 of VDOT Road and Bridge Specifications.
- B. Prime Coat and Tack Coat: Conform to Sections 310 and 311 of VDOT Road and Bridge Specifications.
- C. Reclaimed Asphalt Pavement (RAP): Processed material obtained by milling or full depth removal of existing asphalt concrete pavements. Conform to Section 211 of VDOT Road and Bridge Specifications.
- D. Sand: Fine aggregate, natural sand or stone sand conforming to Section 202 of VDOT Road and Bridge Specifications.
- E. Mineral Filler: Finely ground particles of limestone, hydrated lime or other mineral dust, free of foreign matter.

2.2 ASPHALT PAVING MIXES AND MIX DESIGN

- A. Use dry material to avoid foaming. Mix uniformly.
- B. General: Use Superpave mix design conforming to Section 211 of the VDOT Road and Bridge Specifications.
- C. Wedging or Leveling Mix: Conform to intermediate course.
- D. Submit proposed mix design of each class of mix for review prior to beginning of Work.

2.3 SOURCE QUALITY CONTROL

- A. Obtain materials from plant approved by VDOT.
- B. Test plant samples and mix design in accordance with Section 211 of the VDOT Road and Bridge Specifications.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify utilities indicated under paving are installed with excavations and trenches backfilled and compacted.
- B. Verify compacted subgrade and aggregate base is dry and ready to support paving and imposed loads.
- C. Verify gradients and elevations of base are correct.
- D. Verify utility structure frames and lids are installed in correct position and elevation.

3.2 BASE COURSE

- A. Place and compact base course.
- B. Section 32 1123 - Aggregate Base Courses.

3.3 PREPARATION - PRIMER

- A. Apply primer in accordance with Section 311 of the VDOT Road and Bridge Specifications.
- B. Apply primer to contact surfaces of curbs and gutters.
- C. Use clean sand to blot excess primer.

3.4 PREPARATION - TACK COAT

- A. Apply tack coat in accordance with Section 310 of the VDOT Road and Bridge Specifications.
- B. Apply tack coat on asphalt or concrete surfaces over subgrade surface at uniform rate of 0.05 to 0.10 gallon/sq. yd. (undiluted) and 0.10 to 0.15 gallon/sq. yd. (diluted).
- C. Apply tack coat to contact surfaces of curbs and gutters.
- D. Coat surfaces of manhole, catch basin, and utility structure frames with oil to prevent bond with asphalt pavement. Do not tack coat these surfaces.

3.5 PLACING ASPHALT PAVEMENT - SINGLE COURSE

- A. Install Work in accordance with Section 315 of the VDOT Road and Bridge Specifications.
- B. Place asphalt within 24 hours of applying primer or tack coat.
- C. Place to thickness identified on the Drawings.

- D. Install gutter drainage grilles and frames, manhole frames, and covers in correct position and elevation.
- E. Compact pavement by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- F. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.

3.6 PLACING ASPHALT PAVEMENT - DOUBLE COURSE

- A. Place asphalt binder course within 24 hours of applying primer or tack coat.
- B. Place binder course to thickness identified on the Drawings.
- C. Place wearing course within two hours of placing and compacting binder course.
- D. Place wearing course to thickness identified on the Drawings.
- E. Install gutter drainage grilles and frames, manhole frames, and covers in correct position and elevation.
- F. Compact pavement by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- G. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.

3.7 JOINTS

- A. Transverse Joints
 - 1. When Work is suspended long enough to allow mixture to chill, construct transverse joint.
 - 2. Use butt joint when traffic will not pass over pavement.
 - 3. Use sloped wedge ahead of the end of pavement when traffic will pass over pavement. Place paper parting strip to removal of wedge.
 - 4. Tack coat edge of pavement prior to placing adjoining pavement.
- B. Longitudinal Joints
 - 1. Tack the edge of longitudinal joints prior to placing adjoining pavement.
 - 2. Pinch joint by rolling immediately behind the paver.
 - 3. Offset longitudinal joints in each layer by approximately 6 inches.

3.8 TOLERANCES

- A. Flatness: Maximum variation of 1/4 inch measured with 10 foot straight edge.

- B. Compacted Thickness: Shall be in accordance with Section 315 of the VDOT Road and Bridge Specifications.
- C. Variation from True Elevation: Within 1/2 inch.

3.9 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for general requirements for quality control.
- B. Perform Contractor Quality Control Program in accordance with Section 315 of VDOT Road and Bridge Specifications.
- C. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

3.10 PROTECTION

- A. Immediately after placement, protect pavement from mechanical injury for 7 days or until surface temperature is less than 140 degrees F.

END OF SECTION

This page intentionally left blank

SECTION 32 1723.13 - PAINTED PAVEMENT MARKINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Parking lot markings, including parking bays and curb markings.
- B. "No Parking" curb painting.

1.2 RELATED REQUIREMENTS

- A. Section 32 1216 - Asphalt Paving.

1.3 REFERENCE STANDARDS

- A. AASHTO M 247 - Standard Specification for Glass Beads Used in Pavement Markings 2013.
- B. FHWA MUTCD - Manual on Uniform Traffic Control Devices 2010, with Errata.
- C. FS TT-B-1325 - Beads (Glass Spheres) Retro-Reflective 2007d (Validated 2017).
- D. FS TT-P-1952 - Paint, Traffic and Airfield Marking, Waterborne 2015f (Validated 2020).
- E. MPI (APL) - Master Painters Institute Approved Products List; Master Painters and Decorators Association Current Edition.
- F. VDOT Road and Bridge Standards - Virginia Department of Transportation Road and Bridge Standards 2016.

1.4 SUBMITTALS

- A. See Section 01 3000 - 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. Certificates: Submit for each batch of paint and glass beads stating compliance with specified requirements.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Paint: 2 containers, 1 gallon size, of each type and color.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with Section 704 of VDOT Road and Bridge Specifications.

- B. Maintain one copy of document on site.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section.
- B. Applicator: Company specializing in performing Work of this Section.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver paint in containers of at least 1 gallon.
- B. Deliver glass beads in containers suitable for handling and strong enough to prevent loss during shipment.
- C. Store products in manufacturer's unopened packaging until ready for installation.
- D. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.8 FIELD CONDITIONS

- A. Do not install products under environmental conditions outside manufacturer's absolute limits.
- B. Do not apply materials when surface and ambient temperatures are outside temperature ranges required by paint product manufacturer or:
 - 1. Waterborne Paint: Apply when ambient air temperature and surface temperature is minimum 50 degrees F and rising and at a maximum of 160 degrees F.
 - 2. Thermoplastic: Do not apply until ambient air temperature and temperature of pavement is 50 degrees F or higher.
- C. Do not apply materials during rain or snow when relative humidity is outside humidity ranges, or moisture content of surfaces exceed those required by paint product manufacturer.
- D. Volatile Organic Content (VOC): Do not exceed State or Environmental Protection Agency maximum VOC on traffic paint.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Line and Zone Marking Paint: MPI No. 97 Latex Traffic Marking Paint; white and yellow.
- B. Line and Zone Marking Paint and Preformed Thermoplastic Manufacturers:
 - 1. Accent Stripe, Inc.
 - 2. Crown Technology.
 - 3. Ennis Traffic Safety Solutions, Inc.

4. Epoplex.
 5. Flint Trading.
 6. POLY-CARB, Inc.
 7. Sherwin Williams.
 8. SWARCO.
 9. Substitutions: See Section 01 6000 - Product Requirements.
 10. Furnish materials in accordance with Section 704 of VDOT Road and Bridge Specifications.
- C. Line and Zone Marking Paint:
1. Roadway Markings: As required by authorities having jurisdiction.
 2. Waterborne Paint: Ready mixed, fast dry waterborne traffic paints, lead-free, non-toxic, suitable for roadway or parking lots.
 3. Thermoplastic: Alkyd based ready mixed, fast dry, lead free, non-toxic, for roadways.
 4. Match existing line colors.
 - a. Parking Lot Lines: 4-inch, white.

2.2 EQUIPMENT

- A. Roadway Application for Continuous Longitudinal Lines: Use application equipment with following capabilities:
1. Dual nozzle paint gun to simultaneously apply parallel lines of indicated width in solid or broken patterns or various combinations of those patterns.
 2. Device to heat paint to manufacturer's temperature recommendation for fast dry and thermoplastic applications.
- B. Machine Calibration: Calibrate machines to meet specified tolerances.
- C. 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.
- D. For application of crosswalks, intersections, stop lines, legends, and other miscellaneous items by walk behind strippers, hand spray, or stencil trucks, apply with equipment meeting requirements of this Section. Do not use hand brushes or rollers. Optionally apply glass beads by hand.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- A. Maintenance and Protection of Traffic:
 - 1. Provide short-term traffic control in accordance with Section 01 5000 - Temporary Facilities and Controls.
 - 2. Prevent interference with marking operations and to prevent traffic on newly applied markings before markings dry.
- B. Allow new pavement surfaces to cure for a period of not less than 14 days before application of marking materials.
- C. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- D. 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.
- E. Provide templates to control paint application by type and color at necessary intervals.

3.3 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 the drawings true, sharp edges and ends.
 - 1. Apply paint in one coat only.
 - 2. Wet Film Thickness: 0.015 inch.

3. Length Tolerance: Plus or minus 3 inches.
4. 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.

3.4 APPLICATION TOLERANCES

- A. Section 01 4000 - Quality Requirements: Tolerances.
- B. Maximum Variation from Wet Film Thickness: 1 mil.
- C. Maximum Variation from Wet Paint Line Width: Plus or minus 1/8-inch.
- D. Maximum Variation from Specified Application Temperature: Plus or minus 5 degrees F.

3.5 DRYING, PROTECTION, AND REPLACEMENT

- A. Protect newly painted markings so that paint is not picked up by tires, smeared, or tracked.
- B. Provide barricades, warning signs, and flags as necessary to prevent traffic crossing newly painted markings.
- C. Allow paint to dry at least the minimum time specified by the applicable paint standard and not less than that recommended by the manufacturer.
- D. Repair lines and markings, which after application and curing do not meet following criteria:
 1. Incorrect Location: Remove and replace incorrectly placed patterns.
 2. Insufficient Thickness, Line Width, Paint Coverage, or Glass Bead Coverage (where required): Prepare defective material by acceptably grinding or blast cleaning to remove substantial amount of beads and to roughen marking surface. Remove loose particles and debris. Apply new markings on cleaned surface in accordance with this Section.
 3. Uncured or Discolored Material, Insufficient Bonding: Remove defective markings in accordance with this Section and clean pavement surface one foot beyond affected area. Apply new markings on cleaned surface in accordance with this Section.
- E. Replace failed or defective markings in entire section of defective markings within 30 days after notification when any of the following exists during warranty period:
 1. Marking is discolored or exhibits pigment loss, and is determined to be unacceptable by visual comparison with beaded color plates.

2. If glass beads are used, the average retro-reflectivity is less than 375 mcd/m²/1x for white pavement markings and 250 mcd/m²/1x for yellow pavement markings.
- F. When eradication of existing paint lines is necessary, eradicate by shot blast or water blast method. Do not gouge or groove pavement more than 1/16 inch during removal. Limit area of removal to area of marking plus 1 inch on all sides. Prevent damage to transverse and longitudinal joint sealers, and repair any damage according to requirements in Section 32 1216.
- G. Remove and replace markings that are applied at less than minimum material rates; deviate from true alignment; exceed length and width tolerances; or show light spots, smears, or other deficiencies or irregularities.
1. Remove markings in manner to avoid damage to the surface to which the marking was applied, using carefully controlled sand blasting, approved grinding equipment, or other approved method.
 2. Replace removed markings at no additional cost to Owner.

END OF SECTION

SECTION 32 3113 - CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fence framework, fabric, and accessories.
- B. Excavation for post bases; concrete foundation for posts and center drop for gates.
- C. Manual gates and related hardware.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000-Cast-in-Place Concrete: Concrete anchorage for posts.

1.3 PRICE AND PAYMENT PROCEDURES

- A. Basis of Measurement: Shall not be measured or paid for as a separate pay item. The cost thereof shall be included in the bid price for the item to which it pertains.

1.4 REFERENCE STANDARDS

- A. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength 2018a.
- B. ASTM A121 - Standard Specification for Metallic-Coated Carbon Steel Barbed Wire 2013 (Reapproved 2017).
- C. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- D. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2016a.
- E. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric 2011a (Reapproved 2017).
- F. ASTM A428/A428M - Standard Test Method for Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles 2010 (Reapproved 2014).
- G. ASTM B429/B429M - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube 2010e1.
- H. ASTM F1043 - Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework 2018.
- I. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures 2018.
- J. ASTM F567 - Standard Practice for Installation of Chain-Link Fence 2014a.

- K. CLFMI CLF 2445 - Product Manual - Drawings 2012.
- L. CLF-PM0610 (CLFMI Product Manual) - CLFMI Product Manual 2012.
- M. VDOT Road and Bridge Standards - Virginia Department of Transportation Road and Bridge Standards 2016.

1.5 SUBMITTALS

- A. See Section 01 3000-Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on fabric, posts, accessories, fittings and hardware.
- C. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, and schedule of components.
- D. Manufacturer's Installation Instructions: Indicate installation requirements.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Chain Link Fences and Gates:
 - 1. Master-Halco, Inc.: www.masterhalco.com.
 - 2. Merchants Metals: www.merchantsmetals.com.
 - 3. General Wire & Supply Company: www.generalwireco.com
 - 4. Substitutions: See Section 01 6000 - Product Requirements.

2.2 MATERIALS AND COMPONENTS

- A. Materials and Components: Conform to CLF-PM0610 (CLFMI Product Manual).

2.3 MATERIALS

- A. Steel Pipe Framing: ASTM F1083; Schedule 40 galvanized steel pipe, welded construction; coating conforming to ASTM F1043 Type A on pipe exterior and interior.
- B. Hot Rolled Steel Framing: ASTM A1011/A1011M; hot rolled steel strip, cold formed to pipe configuration, longitudinally welded construction, minimum Grade 50; coating conforming to ASTM F1043 Type B on pipe exterior and interior.
- C. Steel Fence Fabric: ASTM F668 PVC coated.
- D. Concrete: Class A3 conforming to VDOT standards, 3,000 psi strength at 28 days.

2.4 COMPONENTS

- A. Line Posts: 2.38-inch diameter.
- B. Corner and Terminal Posts: 3.5-inch.
- C. Gate Posts:
 - 1. 2.88-inch diameter for gate leaves up to and including 6 feet wide.
 - 2. 4.0-inch diameter for gate leaves over 6 feet and up to and including 13 feet wide.
- D. Top and Brace Rail: 1.66 inch diameter, plain end, sleeve coupled.
- E. Gate Frame: 1.66 inch diameter for welded fabrication.
- F. Fabric: 2-inch diamond mesh interwoven wire, 9 gage thick, top selvage knuckle end closed, bottom selvage knuckle end closed.
- G. Tension Wire: 9 gage thick steel, single strand, as indicated.
- H. Tension Band: 3/16 inch thick steel by 3/4-inch wide steel.
- I. Tension Strap: 3/16 inch thick steel.
- J. Tie Wire: Aluminum alloy steel wire.

2.5 ACCESSORIES

- A. Caps: malleable iron galvanized sized to post diameter, set screw retainer.
- B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings; galvanized steel.
- C. Hardware for Single Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches high, 3 for taller gates; fork latch with gravity drop and padlock hasp; keeper to hold gate in fully open position.
- D. Hardware for Double Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches high, 3 for taller gates; drop bolt on inactive leaf engaging socket stop set in concrete, active leaf latched to inactive leaf with padlock hasp; keepers to hold gate in fully open position.
- E. Privacy Slats: Vinyl or vinyl-coated fabric strips with wings, sized to fit fabric weave and provide 90% blockage.

2.6 FINISHES

- A. Components and Fabric: Vinyl coated over coating of 2.0 oz/sq ft galvanizing.
- B. Hardware: Hot-dip galvanized to weight required by ASTM A153/A153M.
- C. Accessories: Same finish as framing.
- D. Color: Black.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install framework, fabric, accessories and gates in accordance with ASTM F567.
- B. Place fabric on outside of posts and rails.
- C. Set intermediate, terminal, and gate posts plumb in concrete footings with top of footing 2 inches above finish grade. Slope top of concrete for water runoff.
- D. Line Post Footing Depth Below Finish Grade: 2.50 feet (greater than or equal to 6ft fence height).
- E. Corner, Gate and Terminal Post Footing Depth Below Finish Grade: 3 feet.
- F. Brace each gate and corner post to adjacent line post with horizontal center brace rail and diagonal truss rods. Install brace rail one bay from end and gate posts.
- G. Provide top rail through line post tops and splice with 6 inch long rail sleeves.
- H. Install center and bottom brace rail on corner gate leaves.
- I. Do not stretch fabric until concrete foundation has cured 28 days.
- J. Stretch fabric between terminal posts or at intervals of 100 feet maximum, whichever is less.
- K. Position bottom of fabric 2 inches above finished grade.
- L. Fasten fabric to top rail, line posts, braces, and bottom tension wire with tie wire at maximum 15 inches on centers.
- M. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips.
- N. Install bottom tension wire stretched taut between terminal posts.
- O. Install support arms sloped inward, outward, or vertical, as indicated, and attach barbed wire; tension and secure.
- P. Do not attach the hinged side of gate to building wall; provide gate posts.
- Q. Install gate with fabric to match fence. Install hardware.
- R. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings.
- S. Verify vertical and top alignment of posts. Make necessary corrections.
- T. Furnish all gates with Yale and Towne No. 935B padlock or equal with two keys per lock and all locks keyed alike.
- U. Connect to existing fence at existing terminal post, new terminal post, or an existing line post converted to terminal post by installation of brace rails and brace rods.

- V. Install posts with 6 inches maximum clear opening from end posts to buildings, fences and other structures.
- W. Excavate holes for posts to diameter and spacing as recommended by manufacturer.
- X. Center and align posts. Place concrete around posts and vibrate or tamp for consolidation. Verify vertical and top alignment of posts and make necessary corrections.

3.2 TOLERANCES

- A. Maximum Variation From Plumb: 1/4-inch.
- B. Maximum Offset From True Position: 1 inch.
- C. Components shall not infringe adjacent property lines.

END OF SECTION

This page intentionally left blank

SECTION 32 9219 - SEEDING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Hydroseeding, mulching and fertilizer.
- D. Maintenance.

1.2 RELATED REQUIREMENTS

- A. Section 31 2200 - Grading: Preparation of subsoil and placement of topsoil in preparation for the Work of this Section.
- B. Section 31 2323 - Fill: Topsoil material.

1.3 REFERENCE STANDARDS

- A. ASTM D977 - Standard Specification for Emulsified Asphalt 13e1.

1.4 DEFINITIONS

- A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, Brome Grass, and any vegetative species other than specified species to be established in given area.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.
- C. Test Reports: Indicate topsoil nutrient and pH levels with recommended soil supplements and application rates.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer.

1.6 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of seed mixture.

- C. Perform Work in accordance with the Virginia Erosion and Sediment Control Handbook.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable. Deliver seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.
- B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

PART 2 PRODUCTS

2.1 SEED MIXTURE

- A. Permanent Seeding

SPECIES	MINIMUM WEIGHT	MINIMUM PURITY	MINIMUM GERMINATION	SEEDING RATE (LBS PER ACRE)
KENTUCKY 31 OR TURF TYPE TALL FESCUE	90%	97%	85%	225
KENTUCKY BLUEGRASS	10%	97%	85%	25

- B. Temporary Seeding:

SEEDING DATE	SPECIES	MINIMUM WEIGHT	MINIMUM PURITY	MINIMUM GERMINATION	SEEDING RATE (LBS. PER ACRE)
02/16-04/30	ANNUAL RYEGRASS	100%	97%	90%	100
05/01-08/31	GERMAN MILLET	100%	98%	85%	50
09/01-02/15	50/50 MIX OF ANNUAL RYEGRASS & CEREAL RYE	100%	97%	90%	100

2.2 SOIL MATERIALS

- A. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, large stones, waste, debris, contamination, weeds and roots; pH value of minimum 5.5 and maximum 7.5.
- B. Topsoil: Excavated from site and free of weeds.

2.3 ACCESSORIES

A. Mulching Material:

1. Type I mulch shall be Curlex Blanket Erosion Control Fabric manufactured by American Excelsior Company. The fabric shall be manufactured of materials which degrade in 6 to 8 months under outdoor exposure.
2. Type II mulch composed of threshed straw of cereal grain, pine needles, or wood fiber shall be free of objectionable weed seeds or other harmful material.

B. Mulch Binder:

1. Asphalt adhesive for use with Type II mulch shall be emulsified asphalt meeting requirements of ASTM D977, Grade SS-1.
2. Synthetic Mulch Binder for Use with Type II Mulch: Curasol, DCA-70, Petroset, or Terra Tack.

C. Fertilizer: Commercial grade; recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, as indicated by analysis. When test is not available, use mixture to the following proportions:

1. Nitrogen: 10 percent.
2. Phosphoric Acid: 20 percent.
3. Soluble Potash: 10 percent.

D. Water: Clean, fresh and free of substances or matter that could inhibit vigorous growth of grass.

E. Erosion Fabric: See Plans.

F. Herbicide: As required to combat type of weeds encountered.

G. Stakes: Softwood lumber, chisel pointed.

H. String: Inorganic fiber.

I. Lime: Lime shall be ground agricultural grade limestone. Fineness shall be such that 100 percent will pass a No. 20 sieve, and not less than 50 percent will pass a No. 100 sieve. Lime shall be as required by soil testing.

2.4 TESTS

A. Provide analysis of topsoil fill under provisions of Section 01 4000.

B. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.

- C. Testing is not required if recent tests are available for imported topsoil. Submit these test results to the testing laboratory for approval. Indicate, by test results, information necessary to determine suitability.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that prepared soil base is ready to receive the work of this Section.

3.2 PREPARATION

- A. Prepare subgrade in accordance with Section 31 2200.
- B. Place topsoil in accordance with Section 31 2200.

3.3 FERTILIZING

- A. Apply fertilizer in accordance with manufacturer's instructions at a rate recommended by soil analysis.
- B. Apply after smooth raking of topsoil and prior to roller compaction.
- C. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
- D. Mix thoroughly into upper 3 inches of topsoil.
- E. Lightly water to aid the dissipation of fertilizer. Irrigate top level of soil uniformly.
- F. Permanent Seeding Season:
 - 1. Appalachian Region:
 - a. Fall: August 15 - November 1.
 - b. Spring: March 1 - June 1.

3.4 SEEDING

- A. Apply seed at a rate evenly in two intersecting directions. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Permanent Seeding Season:
 - 1. Appalachian Region:
 - a. Fall: August 15 - November 1.
 - b. Spring: March 1 - June 1.
- D. Do not sow immediately following rain, when ground is too dry, or during windy periods when winds are over 12 mph.

- E. Immediately following seeding, apply mulch at a rate of 4,500 lbs./acre or 2 bales per 1,000 square feet. Remove straw clumps from seeded area. Maintain clear of shrubs and trees.
- F. Apply water with a fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.
- G. Following germination, immediately re-seed areas without germinated seeds that are larger than 4 by 4 inches.

3.5 HYDROSEEDING

- A. Apply fertilizer, mulch, and seeded slurry with a hydraulic seeder at a rate of 6 lbs per 1,000 square foot evenly in two intersecting directions.
- B. Apply water with a fine spray immediately after each area has been hydroseeded. Saturate to 4 inches of soil and maintain moisture levels 2 to 4 inches.
- C. Following germination, immediately re-seed areas without germinated seeds that are larger than 8 by 8 inches.

3.6 PROTECTION

- A. Cover seeded slopes where grade is 3H:1V or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.
- B. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Provide 12 inch overlap of adjacent rolls. Backfill trench and rake smooth, level with adjacent soil.
- C. Secure outside edges and overlaps at 36 inch intervals with stakes.
- D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.7 MAINTENANCE

- A. Warranty all seeded areas within 1 year from date of acceptance.
- B. Maintain seeded areas immediately after placement until grass is well established and exhibits a vigorous growing condition. In the event that growth is not established by final project inspection, continue the specified attention until acceptance by Owner.
- C. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at any one mowing.
- D. Neatly trim edges and hand clip where necessary.
- E. Immediately remove clippings after mowing and trimming.
- F. Water to prevent grass and soil from drying out.

- G. Roll surface to remove minor depressions or irregularities.
- H. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions.
Remedy damage resulting from improper use of herbicides.
- I. Immediately reseed areas that show bare spots.
- J. Protect seeded areas with warning signs during maintenance period.

END OF SECTION

SECTION 32 9223 - SODDING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Fertilizing.
- D. Sod installation.
- E. Maintenance.

1.2 RELATED REQUIREMENTS

- A. Section 31 2200 - Grading: Topsoil material.
- B. Section 31 2200 - Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.
- C. Section 31 2323 - Fill: Topsoil material.

1.3 DEFINITIONS

- A. Weeds: Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.4 REFERENCE STANDARDS

- A. TPI (SPEC) - Guideline Specifications to Turfgrass Sodding 2006.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Certificate: Certify grass species and location of sod source.
- C. Certificate: Certify fertilizer and herbicide mixture approval by authority having jurisdiction.
- D. Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer .
- E. Maintenance Contract.

1.6 QUALITY ASSURANCE

- A. Sod Producer: Company specializing in sod production and harvesting with minimum five years experience, and certified by the State of Virginia.

1.7 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.
- B. Installer Qualifications: Company approved by the sod producer.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Provide certificate of compliance from authority having jurisdiction indicating approval of fertilizer and herbicide mixture.
- B. Deliver sod on pallets. Protect exposed roots from dehydration.
- C. Do not deliver more sod than can be laid within 24 hours.

1.9 MAINTENANCE

- A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of fertilizer and herbicide mixture.

2.2 MATERIALS

- A. Sod: TPI (SPEC), Certified Turfgrass Sod quality; cultivated grass sod; type indicated below; with strong fibrous root system, free of stones, burned or bare spots; containing no more than 5 weeds per 1000 sq ft. Minimum age of 18 months, with root development that will support its own weight without tearing, when suspended vertically by holding the upper two corners.
 - 1. Tall Fescue Grass Type: 90 percent.
 - 2. Thickness: "Thick" sod, minimum 1 inch and maximum 1-3/8 inch topsoil base.
 - 3. Cut sod in area not exceeding 1 sq yd.
 - 4. Machine cut sod and load on pallets in accordance with TPI (SPEC) Guidelines.
- B. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay, or impurities, plants, weeds and roots; pH value of minimum 5.4 and maximum 7.0.
- C. Fertilizer: _____; recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, as indicated by analysis.

2.3 ACCESSORIES

- A. Wood Pegs: Softwood, sufficient size and length to ensure anchorage of sod on slope.
- B. Wire Mesh: Interwoven hexagonal metal wire mesh of 2 inch size.

2.4 SOURCE QUALITY CONTROL

- A. Provide analysis of topsoil fill under provisions of Section 01 4000.
- B. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.
- C. Submit minimum 10 oz sample of topsoil proposed. Forward sample to approved testing laboratory in sealed containers to prevent contamination.
- D. Testing is not required if recent tests are available for imported topsoil. Submit these test results to the testing laboratory for approval. Indicate, by test results, information necessary to determine suitability.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that prepared soil base is ready to receive the work of this section.

3.2 PREPARATION

- A. Prepare subgrade in accordance with Section 31 2200.
- B. Place topsoil in accordance with Section 31 2200.

3.3 FERTILIZING

- A. Apply fertilizer in accordance with manufacturer's instructions.
- B. Apply after smooth raking of topsoil and prior to installation of sod.
- C. Apply fertilizer no more than 48 hours before laying sod.
- D. Mix thoroughly into upper 2 inches of topsoil.
- E. Lightly water to aid the dissipation of fertilizer.

3.4 LAYING SOD

- A. Moisten prepared surface immediately prior to laying sod.
- B. Lay sod immediately after delivery to site to prevent deterioration.
- C. Lay sod smooth and tight with no open joints visible, and no overlapping; stagger end joints 12 inches minimum. Do not stretch or overlap sod pieces.

- D. Where new sod adjoins existing grass areas, align top surfaces.
- E. Where sod is placed adjacent to hard surfaces, such as curbs, pavements, etc., place top elevation of sod 1/2 inch below top of hard surface.
- F. On slopes 6 inches per foot and steeper, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet on center. Drive pegs flush with soil portion of sod.
- G. Prior to placing sod, on slopes exceeding 8 inches per foot or where indicated, place wire mesh over topsoil. Securely anchor in place with wood pegs sunk firmly into the ground.
- H. Water sodded areas immediately after installation. Saturate sod to 4 inches of soil.
- I. After sod and soil have dried, roll sodded areas to ensure good bond between sod and soil and to remove minor depressions and irregularities. Roll sodded areas with roller not exceeding ____ lbs.

3.5 MAINTENANCE

- A. Provide maintenance at no extra cost to Owner; Owner will pay for water.
- B. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- C. Maintain sodded areas immediately after placement until grass is well established and exhibits a vigorous growing condition.
- D. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at any one mowing.
- E. Neatly trim edges and hand clip where necessary.
- F. Immediately remove clippings after mowing and trimming.
- G. Water to prevent grass and soil from drying out.
- H. Roll surface to remove irregularities.
- I. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.
- J. Immediately replace sod to areas that show deterioration or bare spots.
- K. Protect sodded areas with warning signs during maintenance period.

END OF SECTION

SECTION 33 0132 - SEWER AND MANHOLE TESTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Gravity Sewer Testing:
 - 1. Low-pressure Air Test.
 - 2. Exfiltration Test.
 - 3. Infiltration Test.
- B. Deflection Testing of Plastic Piping.
- C. Manhole Testing:
 - 1. Vacuum Test.
 - 2. Infiltration Test
 - 3. Exfiltration Test.

1.2 RELATED REQUIREMENTS

- A. Section 33 0513 - Manholes and Structures.
- B. Section 33 3111 - Sanitary Utility Sewerage Piping.

1.3 REFERENCE STANDARDS

- A. ASTM International:
 - 1. ASTM C828 - Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipelines; 2011.
 - 2. ASTM C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test; 2011.
 - 3. ASTM D2122 - Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings; 2015.
 - 4. ASTM F1417 - Standard Test Method for the Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air; 2011.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Submit the following prior to start of testing:
 - 1. Testing procedures.

2. List of test equipment.
 3. Testing sequence schedule.
 4. Provisions for disposal of flushing and test water.
 5. Certification of test gauge calibration.
 6. Deflection mandrel drawings and calculations.
- C. Test Reports: Indicate results of manhole and piping tests.

PART 2 PRODUCTS - NOT USED.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that manholes and piping are ready for testing.
- B. Verify trenches are backfilled.
- C. Verify pressure piping concrete reaction support blocking or mechanical restraint system is installed.

3.2 PIPING PREPARATION

- A. Flush and clean piping.
- B. Assist Engineer in lamping gravity piping.
 1. Engineer will perform lamping operation by shining light at one end of each pipe section between manholes; observe light at other end; pipe shall exhibit a full circle of light; reject pipe not installed with uniform line and grade
 2. Remove and reinstall rejected pipe sections; re-clean and assist Engineer with re-lamping.
- C. Plug outlets, wye-branches, and laterals; brace plugs to resist test pressures.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Notify Engineer 72 hours in advance of tests. Engineer shall witness tests.
- C. Tests shall be conducted on short sections of sewer line, i.e., between manholes, or at the end of each day's Work. Installation of sewers will not be permitted at a point more than 2,000 feet ahead of any section of sewer which has not been given the final test and accepted. Provide all labor, materials, tools, and equipment necessary to make the tests. All equipment and methods used shall be acceptable to Engineer. All monitoring gages shall be subject to calibration, if deemed necessary. All sewer lines, regardless of size, that cross under streams

shall be tested for and exhibit zero infiltration.

3.4 TESTING GRAVITY SEWER PIPING

A. Low-pressure Air Test:

1. Perform test in accordance with applicable portions of ASTM C828 and ASTM F1417.
2. Test each section of gravity sewer piping between manholes.
3. Introduce air pressure slowly to approximately 4 psig.
4. Determine groundwater elevation above spring line of pipe. For every foot of groundwater above spring line of pipe, increase starting air test pressure by 0.43 psig; do not increase pressure above 10 psig.
5. Allow pressure to stabilize for at least five minutes. Adjust pressure to 3.5 psig or increased test pressure as determined above when groundwater is present. Start test.
6. Determine test duration for sewer section with single pipe size from the following table. Do not make allowance for laterals.

Normal Pipe Size (Inches)	Minimum Test Time (min/100 feet)
4	0.3
6	0.7
8	1.2

7. Record drop in pressure during test period; when air pressure has dropped more than 1.0 psig during test period, piping has failed; when 1.0 psig air pressure drop has not occurred during test period, discontinue test and piping is accepted.
8. When piping fails, determine source of air leakage, make corrections and retest; test section in incremental stages until leaks are isolated; after leaks are repaired, retest entire section between manholes.

B. Exfiltration Test:

1. Test pipe larger than 36 inch diameter with exfiltration test not exceeding 100 gallons for each inch of pipe diameter for each mile per day for each section under test. Perform test with minimum positive head of 4 feet.

C. Infiltration Test

1. Use only when gravity piping is submerged in groundwater minimum of 4 feet above crown of pipe for entire length being tested.
2. Maximum Allowable Infiltration: 100 gallons per inch of pipe diameter for each mile per day for section under test; include allowances for leakage from manholes. Perform test with minimum positive head of 4 feet.

3.5 DEFLECTION TESTING OF PLASTIC PIPING

- A. Perform vertical ring deflection testing on PVC sewer piping after backfilling has been in place for at least 30 days but not longer than 12 months.
- B. Allowable maximum deflection for installed plastic sewer pipe is limited to 5 percent of original vertical internal diameter.
- C. Furnish rigid ball or mandrel with diameter not less than 95 percent of base or average inside diameter of pipe as determined by ASTM standard to which pipe is manufactured. Measure pipe in compliance with ASTM D2122.
- D. Perform deflection testing using properly sized rigid ball or 'Go, No-Go' mandrel.
- E. Perform test without mechanical pulling devices.
- F. Locate, excavate, replace, and retest pipe exceeding allowable deflection.

3.6 TESTING MANHOLES

- A. General: Test using air whenever possible prior to backfilling to assist in locating leaks. Make joint repairs on both outside and inside of joint to ensure permanent seal. Test manholes with manhole frame set in place.
- B. Vacuum test in accordance with ASTM C1244 and as follows:

- 1. Plug pipe openings; securely brace plugs and pipe.
- 2. Inflate compression band to affect seal between vacuum base and structure; connect vacuum pump to outlet port with valve open; draw vacuum to 10 inches of Hg; close valve; start test.
- 3. Determine test duration for 4-foot diameter manhole from the following table:

Manhole Depth	Test Period
10 feet or less	60 seconds
>10 feet but <15 feet	75 seconds
>15 feet but <25 feet	90 seconds

- 4. For manholes 5 feet in diameter, add an additional 15 seconds and for manholes 6 feet in diameter, add an additional 30 seconds to the time requirements for 4-foot diameter manholes.
- 5. Record vacuum drop during test period; when vacuum drop is greater than 1 inch of Hg during test period, repair and retest manhole; when vacuum drop of 1 inch of Hg does not occur during test period, discontinue test and accept manhole.
- 6. When vacuum test fails to meet 1 inch Hg drop in specified time after repair, repair and retest manhole.
- C. Infiltration Test:
 - 1. Determine groundwater level.

2. Use infiltration test when groundwater is at least 4 feet above top of pipe for the entire length of line to be tested.
3. Plug the pipe at the upper manhole.
4. Install suitable measuring device at the next lowest manhole.
5. Measure the amount of water flowing through the outlets over a 30-minute period. Maximum allowable leakage shall be limited to 1/2 gallon per hour per manhole plus maximum allowable sewer line leakage for the test section.
6. Maximum allowable leakage for sewer lines shall be 2,400 gallons per day per mile or 100 gallons per day per inch pipe diameter per mile, whichever is less.

D. Exfiltration Test:

1. Determine groundwater level.
2. Use exfiltration test when groundwater is less than 4 feet above top of pipe.
3. Plug pipes in manhole; remove water in manhole; observe plugs over period of not less than 2 hours to ensure there is no leakage into manhole.
4. Fill manhole with water to within 4 inches of top of cover frame. Prior to test, allow manhole to soak for a maximum of 12 hours. The cover shall be on the manhole during the soaking period. After soak period, adjust water level inside manhole to within 4 inches of top of cover frame.
5. Measure water level from top of manhole frame; at end of 30 minute test period, again measure water level from top of manhole frame; compute drop in water level during test period.
6. Manhole exfiltration test shall not exceed 1/2 gallon per hour.
7. When unsatisfactory test results are achieved, repair manhole and retest until result meets criteria; repair visible leaks regardless of quantity of leakage.
8. Upon completion of the test, the water shall be removed from the manhole.

END OF SECTION

This page intentionally left blank

SECTION 33 0513 - MANHOLES AND STRUCTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Monolithic concrete manholes with masonry transition to lid frame, covers, anchorage, and accessories.
- B. Modular precast concrete manhole sections with tongue-and-groove joints with masonry transition to lid frame, covers, anchorage, and accessories.
- C. Monolithic FRP manholes with transition to lid frame, covers, anchorage, and accessories.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.

1.3 REFERENCE STANDARDS

- A. ACI 530/530.1/ERTA - Building Code Requirements and Specification for Masonry Structures and Related Commentaries; American Concrete Institute International; 2013.
- B. ASTM A48/A48M - Standard Specification for Gray Iron Castings; 2003 (Reapproved 2012).
- C. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2015.
- D. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; 2015.
- E. ASTM C443 - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets; 2012.
- F. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections; 2013.
- G. ASTM C478M - Standard Specification for Precast Reinforced Concrete Manhole Sections [Metric]; 2014.
- H. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile; 2015.
- I. ASTM C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures; 2014.
- J. ASTM C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Section Precast Concrete Water and Wastewater Structures; 2013.
- K. ASTM C891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures; 2011.
- L. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures; 2008.

- M. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals; 2008 (Reapproved 2013).
- N. ASTM C923M - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals [Metric]; 2008b (Reapproved 2013).
- O. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Section Using Preformed Flexible Joint Sealants; 2009.
- P. ASTM D3753 - Standard Specification for Glass-Fiber-Reinforced Polyester Manholes and Wet Wells; 2012.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate manhole locations, elevations, piping sizes and elevations of penetrations.
- C. Product Data: Provide manhole covers, component construction, features, configuration, and dimensions.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Manufacturer's Qualification Statement.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section and certified by NPCA Plant Certification program prior to and during Work of this Section.
- B. Obtain precast structures from a single source.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Section 01 6000 - Product Requirements: Product storage and handling requirements.
- B. Comply with precast concrete manufacturer's instructions and ASTM C913 for unloading, storing and moving precast manholes and drainage structures.
- C. Store precast concrete manholes and drainage structures to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.
- D. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

1.7 FIELD CONDITIONS

- A. Cold and Hot Weather Requirements: Comply with requirements of ACI 530/530.1/ERTA or applicable building code, whichever is more stringent.

- B. Maintain materials and surrounding air temperature to minimum 50 degrees F prior to, during, and 48 hours after completion of masonry work.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Manhole Sections: Reinforced precast concrete in accordance with ASTM C478 (ASTM C478M), with resilient connectors complying with ASTM C923 (ASTM C923M).
- B. Manhole Sections: ASTM D3753, glass-fiber reinforced polyester with integral steps.
- C. Concrete: As specified in Section 03 3000.
- D. Joints for concrete pipe and manholes, using rubber gaskets in accordance with ASTM C443.
- E. Joints for concrete pipe, manholes, and box sections using preformed flexible joint sealants in accordance with ASTM C990.
- F. Concrete Reinforcement: As specified in Section 03 3000.

2.2 COMPONENTS

- A. Standard Frames and Covers:
 - 1. Lid and Frame: ASTM A48/A48M, Class 30B Cast iron construction, machined flat bearing surface, removable lockable lid, closed lid design; live load rating of HS20 in paved/traffic areas; sealing gasket. Size, shape, and lettering as indicated on Drawings.
- B. Steps: Conform to ASTM C478 and current OSHA Regulations, minimum 12 inches wide spaced vertically 16 inches on center, made of copolymer polypropylene plastic encapsulating 1/2-inch grade 60 steel reinforcement. Vertical load resistance of 400 lbs. and minimum pull-out resistance of 1,000 lbs.
- C. Strap Anchors: Stainless steel capable of supporting pipe or accessories indicated on Drawings, minimum 1-inch wide x 1/8-inch thick.

2.3 CONFIGURATION

- A. Provide size and shape as indicated on Drawings.
- B. Foundation Slab: Cast-in-place or precast reinforced concrete integral with bottom section, level top surface.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify items provided by other sections of Work are properly sized and located.
- B. Verify that built-in items are in proper location, and ready for roughing into Work.

- C. Verify excavation for manholes is correct.

3.2 PREPARATION

- A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.
- B. Excavate and place bedding. See Section 31 2316.13 for additional trenching requirements.

3.3 MANHOLES

- A. Place concrete base pad, trowel top surface level.
- B. Place manhole sections plumb and level, trim to correct elevations, anchor to base pad.
- C. Form and place manhole cylinder plumb and level, to correct dimensions and elevations. As work progresses, build in fabricated metal items.
- D. Cut and fit for pipe.
- E. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as required.
- F. Set cover frames and covers level without tipping, to correct elevations.
- G. Coordinate with other sections of work to provide correct size, shape, and location.

END OF SECTION

SECTION 33 1116 - WATER UTILITY DISTRIBUTION PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe and fittings for water lines including domestic water lines and fire water lines.
- B. Tied Joint Restraint System.
- C. Valves, Fire hydrants, Domestic water hydrants, and Meters.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete for thrust restraints.
- B. Section 31 2316 - Excavation: Excavating of trenches.
- C. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.
- D. Section 31 2323 - Fill: Bedding and backfilling.
- E. Section 33 0513 - Manholes and Structures.
- F. Section 33 1300 - Disinfecting of Water Utility Distribution: Disinfection of utility water piping.

1.3 REFERENCES

- A. AASHTO HB - Standard Specifications for Highway Bridges; Seventeenth Edition.
- B. ASME B16.3 - Malleable Iron Threaded Fittings Classes 150 and 300; 2011.
- C. ASME B16.4 - Gray Iron Threaded Fittings Classes 125 and 250; 2011.
- D. ASME B18.2.2 - Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series); 2010.
- E. ASME B18.5.2.1M - Metric Round Head Short Square Neck Bolts; 2006 (Reaffirmed 2011).
- F. ASME B18.5.2.2M - Metric Round Head Square Neck Bolts; 1982 (Reaffirmed 2010).
- G. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength; 2014.
- H. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength; 2014.
- I. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts; 2007a (Reapproved 2014).
- J. ASTM A563M - Standard Specification for Carbon and Alloy Steel Nuts [Metric]; 2007.

- K. ASTM A588/A588M - Specification for High Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 in. (100 mm) Thick; 2015.
- L. ASTM B633 - Specification for Electrodeposited Coating of Zinc on Iron and Steel; 2013.
- M. ASTM D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Plastic Pipe Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds; 2011.
- N. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2012.
- O. ASTM D2239 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled inside Diameter; 2012.
- P. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2015.
- Q. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40; 2015.
- R. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings; 1996 (Reapproved 2010).
- S. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals; 1998 (Reapproved 2011).
- T. ASTM F436 - Specification for Hardened Steel Washers; 2011.
- U. AWWA C104/A21.4 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings; American Water Works Association; 2008 (ANSI/AWWA C104/A21.4).
- V. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems; American Water Works Association; 2010 (ANSI/AWWA C105/A21.5).
- W. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; American Water Works Association; 2012 (ANSI/AWWA C111/A21.11).
- X. AWWA C115/A21.15 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges; 2011.
- Y. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast; American Water Works Association; 2009 (ANSI/AWWA C151/A21.51).
- Z. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service; American Water Works Association; 2009.
- AA. AWWA C502 - Dry Barrel Fire Hydrants; American Water Works Association (ANSI/AWWA C502/C502a); 2014.
- BB. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service; American Water Works Association; 2009 (ANSI/AWWA C509).

- CC. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances; American Water Works Association; 2010 (ANSI/AWWA C600).
- DD. AWWA C602 - Cement-Mortar Lining of Water Pipelines in Place, 4 In. (100 mm) and Larger; 2011.
- EE. AWWA C606 - Grooved and Shouldered Joints; American Water Works Association; 2011.
- FF. UL 246 - Hydrants for Fire-Protection Service; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting at least one month prior to the start of the work of this section; require attendance by all affected installers.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, hydrants and accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Project Record Documents: Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.
- E. Tied Joint Restraint System:
 - 1. Shop Drawings: Indicate restrained joint details and materials being utilized. Submit layout drawings showing piece numbers and locations. Also, indicate restrained joint locations.
 - 2. Product Data: Submit catalog data for restrained joint details and installation instructions.
 - 3. Design Data: Submit design calculations showing determination of restrained lengths and submit joint restraint details. Use joint restraint devices specifically designed for applications described in manufacturer's data.
 - 4. Manufacturer's Installation Instructions: Submit installation instructions.
 - 5. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with utility company requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers with labeling in place including manufacturer's name and pressure rating.
- B. Stockpile pipe in locations agreed upon by Owner, Contractor, and Architect/Engineer.

PART 2 PRODUCTS

2.1 WATER PIPE

- A. Ductile Iron Pipe (DIP): AWWA C151. Bituminous outside coating: AWWA C151; marked with NSF 61 designation for potable water use. Cement Mortar Lining: AWWA C104.
 - 1. Pressure Rating:
 - a. 3" to 12" Pipe: Pressure Class 350.
 - b. 14" Pipe and Greater: As scheduled on the Drawings.
 - 2. Fittings: Ductile iron, AWWA C110. Compact fittings, ductile iron, AWWA C153.
 - a. Pressure Rating: Equal to pressure of adjacent piping system.
 - b. Bituminous Coating: AWWA C110.
 - c. Cement Mortar Lining: AWWA C104.
 - 3. Joints:
 - a. Mechanical and Push-On Joints: AWWA C111.
 - b. Flanged Joints: AWWA C115.
 - c. Boltless Restrained Joints: Boltless, push-on type, joint restraint independent of joint seal. Conform to pipe manufacturer's specifications.
 - d. Tied Restrained Joints: Per Section 33 0519.
- B. PVC Pipe: AWWA C900 and AWWA C905; marked with NSF 61 designation for potable water use.
 - 1. Pipe Class: DR 17, 250 psi for 2".
 - 2. Pipe Class: DR 18, 235 psi for 4" through 12".
 - 3. Fittings:
 - a. PVC, AWWA C900 and AWWA C905.
 - b. Ductile Iron, Mechanical Joint, AWWA C110.
 - 4. Joints:

- a. PVC, ASTM D3139 with ASTM F477 PVC flexible elastomeric seals. Solvent-cement couplings are not permitted.
- b. Ductile Iron, Mechanical Joint, AWWA C111.
- c. Boltless Restrained Joints: Boltless, push on type, joint restraint independent of joint seal. Conform to pipe manufacturer's specifications.

2.2 VALVES

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Resilient Wedge Gate Valves
 - 1. Manufacturers:
 - a. American Flow Control.
 - b. Clow Valve Company.
 - c. Mueller Co.
 - d. Substitutions: Equal per Section 01 6000 - Product Requirements.
 - 2. Furnish materials in accordance with utility company or governing agency requirements.
 - 3. Resilient Wedge Gate Valves: UL listed for 2", AWWA C509 for 3" through 36"; iron body, bronze or ductile iron.
 - a. Resilient seats.
 - b. Stem: Rising bronze stem (3" and smaller); non-rising bronze stem (4" and larger).
 - c. Operating Nut: Square; open counterclockwise unless otherwise indicated.
 - d. Ends: Flanged, mechanical joint or bell end connections.
 - e. Coating: AWWA C550; interior/exterior.
 - f. Sizes 12-Inch Diameter and Smaller: Equal to pressure of adjacent piping system.
- C. Ball Valves Up To 2 Inches:
 - 1. Manufacturers:
 - a. Crane; Crane Energy Flow Solutions.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.

- e. Stockham; Crane Energy Flow Solutions.
 - f. Substitutions: Equal per Section 01 6000 - Product Requirements.
- 2. Brass or bronze body, teflon or chrome coated brass or bronze ball, teflon seats and rubber stem seals, tee stem pre-drilled for control rod, AWWA inlet end, compression outlet with electrical ground connector, with control rod, valve key, blowout proof stem, and extension box.
 - 3. Pressure rating equal to or greater than adjacent piping.
- D. Valve Boxes:
- 1. Valves 12-Inch Diameter and Smaller: Cast-iron, two-piece, as manufactured by Sigma, or approved equal.
 - 2. Cast iron lid marked "WATER".

2.3 TIED JOINT RESTRAINT SYSTEM

- A. Manufacturers:
- 1. Dresser Piping Specialties.
 - 2. Ebaa Iron Sales, Inc.
 - 3. Star Pipe Products, Inc.
 - 4. Substitutions: Equal per Section 01 6000 - Product Requirements.
- B. Steel Types:
- 1. High Strength Low-Alloy Steel, ASTM A588, heat-treated.
 - 2. High Strength Low-Alloy Steel, ASTM A588.
 - 3. Carbon Steel ASTM A36.
- C. Components:
- 1. Tie Bolts:
 - a. 5/8-inch for 2-inch and 3-inch mechanical joints, 3/4 inch for 4 inch to 12 inch mechanical joints and flanged joints, ASTM A588, Grade B; ASTM A325, Type 3, except increase tensile strength of full-body threaded section to 40,000 pounds minimum for 5/8 inch and 60,000 pounds minimum for 3/4 inch by heat-treating (quenching and tempering) to manufacturer's reheat and hardness specifications.
 - b. 3/4-inch for 14-inch to 24-inch mechanical joints, ASTM A588, Grade B; ASTM A325, Type 3.

- c. 1 inch for 30-inch and larger mechanical joints and flanged joints, ASTM A588, Grade B; ASTM A325, Type 3; except increase tensile strength of full-body thread section to 100,000 pounds minimum by heat-treating (quenching and tempering) to manufacturer's reheat and hardness specifications.
- 2. Tie Nut: Hex nut for each tie bolt and tie rods.
 - a. ASTM A563, Grade C3; plain, zinc plated, or galvanized.
- 3. Tiepin: 3/4-inch round bar stock for use on bends and hydrants.
 - a. 6-inch hairpin shape, ASTM A588; ANSI B1.1; plain, zinc plated, or galvanized.
- 4. Tie Coupling: Used to extend continuous threaded rods and provided with center stop to aid installation.
 - a. ASTM A588; plain, zinc plated, or galvanized.
- 5. Tie Clamp: Retainer clamp for ductile iron, asbestos cement and polyvinyl chloride, push-on pipe in front of bell.
 - a. ASTM A36; ASTM A307 Grade A; ASTM A563, Grade A; plain, zinc plated, or galvanized.
- 6. Tie Rod: Continuous threaded rod for cutting to desired lengths.
 - a. ASTM A588, Grade B; ASTM A325, Type 3; ANSI B1.1; plain zinc plated, or galvanized.
- 7. Tie Bar: Steel bar used to restrain push-in plugs.
 - a. ASTM A36; plain, zinc plated, or galvanized.
- 8. Tie Washer: Round flat washers.
 - a. ASTM A588, ASTM F436, Type 3; plain, zinc plated, or galvanized.
- 9. Factory Applied Finishes: Zinc plated or galvanized to meet the following requirements:
 - a. ASTM B633 for electrodeposited coating of zinc on steel.
 - b. ASTM A153 for galvanizing iron and steel hardware.
 - c. Galvanizing for rolled, pressed, and forged steel shapes: ASTM A123; minimum 2.0 ounces per square foot coating thickness; galvanize after fabrication.

2.4 HYDRANTS

- A. Hydrants: Type as required by utility company.
- B. Manufacturers:
 - 1. American Darling.

2. Kennedy Valve.
 3. Mueller Co.
 4. Substitutions: Equal per Section 01 6000 - Product Requirements.
- C. Dry-barrel Break-away Type: AWWA C502; cast-iron body, compression type valve.
1. Bury Depth: As indicated on the Drawings.
 2. Inlet Connection: 6 inches.
 3. Valve Opening: 5-1/4 inch diameter.
 4. Ends: Mechanical Joint or Bell End.
 5. Bolts and Nuts: Corrosion resistant.
 6. Coating: AWWA C550; interior.
 7. Direction of Opening: Counterclockwise unless otherwise indicated.
- D. One pumper, two hose nozzles.
1. Obtain thread type and size from local fire department.
 2. Attach nozzle caps by separate chains.
- E. Finish: Primer and two coats of enamel in color required by Owner.
- F. Extended Warranty: Provide manufacturer's warranty for one (1) year beyond the construction warranty. The warranty shall cover full replacement of any fire hydrant that fails, or any portion thereof, that causes poor performance of the hydrant.

2.5 BEDDING AND COVER MATERIALS

- A. Bedding: As specified in Section 31 2316.13.
- B. Cover: As specified in Section 31 2316.13.

2.6 ACCESSORIES

- A. Concrete for Thrust Restraints: Concrete type specified in Section 03 3000.
- B. Manhole and Cover: Refer to Section 33 0513.
- C. Pipeline Markers:
1. Underground Pipeline Markers
 - a. Description: Plastic Ribbon and Trace Wire Tape: Bright colored blue, continuously printed with "WATER SERVICE" in large letters, minimum 6 inches wide by 4 mil thick, with magnetic detectable conductor manufactured for direct burial service.

- b. Underground pipe markers shall be required for non-metallic pipe only.
- D. Polyethylene Jackets: AWWA C105 8 mil polyethylene jacket. Double layer, lapped over pipe joint, and secured with 10 mil polyethylene tape.
- E. Steel Rods, Bolt, Lugs and Brackets: ASTM A36 or ASTM A307 Grade A carbon steel.
- F. Heat Tape
 - 1. Heating Cable
 - a. Manufacturers:
 - 1) Raychem Model H612 Wintergard wet self-regulating heating cable.
 - b. Substitutions: Equal per Section 01 6000 - Product Requirements.
 - 2. Plug
 - a. Manufacturers:
 - 1) Raychem Model H908 plug-in power connection kit with end seal.
 - b. Substitutions: Equal per Section 01 6000 - Product Requirements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. See Section 01 7000 - Execution and Closeout Requirements for verification of existing conditions before starting Work.
- B. Verify that building service connection and municipal utility water main size, location, and invert are as indicated.

3.2 PREPARATION

- A. Remove scale and dirt on inside and outside before assembly.
- B. Prepare pipe connections to equipment with flanges or unions.

3.3 TRENCHING

- A. See the Section 31 2316.13 - Trenching for additional requirements.
- B. Hand trim excavation for accurate placement of pipe to elevations indicated.
- C. Form and place concrete for pipe thrust restraints at each change of pipe direction. Place concrete to permit full access to pipe and pipe accessories. Provide thrust restraints as shown on Drawings.
- D. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.4 BACKFILLING

- A. Backfill and compact around sides and to top of pipe in accordance with Section 31 2316.13.
- B. Maintain optimum moisture content of bedding material to attain required compaction density.

3.5 INSTALLATION - PIPE

- A. Install ductile iron pipe and fittings in accordance with AWWA C600.
- B. Install PVC pipe in accordance with AWWA C605 and manufacturer's instructions.
- C. Handle and assemble pipe in accordance with manufacturer's instructions and as indicated on Drawings.
- D. Steel Rods, Bolt, Lugs, and Brackets: Coat buried steel with one coat of coal tar coating before backfilling.
- E. Normal Conditions: Maintain 10 ft. horizontal and 18-inch vertical separation of water main from sewer piping or as required by local code.
- F. Unusual Conditions: When local conditions prevent a horizontal separation of at least 10 feet, the water line may be laid closer to a sewer or sewer manhole provided that:
 - 1. The bottom of the water line is at least 18 inches above the top of the sewer.
 - 2. Where this vertical separation cannot be obtained, the sewer shall be constructed of AWWA-approved water pipe pressure-tested in place to 50 psi without leakage prior to backfilling. The sewer manhole shall be of watertight construction and tested in place.
- G. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs. Use only equipment specifically designed for pipe cutting. The use of chisels or hand saws shall not be permitted. Grind edges smooth with beveled end for push-on connections.
- H. Flanged Joints: Not to be used in underground installations except within structures.
- I. Route pipe in straight line. Relay pipe that is out of alignment or grade.
- J. Sanitary and/or Combined Sewers or Sewer Manholes: No water pipes shall pass through or come in contact with any part of a sewer or sewer manhole.
- K. Install pipe with no high points. If unforeseen field conditions arise which necessitate high points, install air release valves as directed by Engineer.
- L. Install pipe to have bearing along entire length of pipe. Excavate bell holes to permit proper joint installation. Do not lay pipe in wet or frozen trench.
- M. Prevent foreign material from entering pipe during placement.
- N. Install pipe to allow for expansion and contraction without stressing pipe or joints.

- O. Close pipe openings with watertight plugs during work stoppages.
- P. Install access fittings to permit disinfection of water system performed under Section 33 1300.
- Q. Group piping with other site piping work whenever practical.
- R. Establish elevations of buried piping with not less than 3 ft. of cover. Measure depth of cover from final surface grade to top of pipe barrel.

3.6 INSTALLATION - VALVES AND HYDRANTS

- A. Install valves in conjunction with pipe installation; set valves plumb.
- B. Provide buried valves with valve boxes installed flush with finished grade.
- C. Install hydrants; provide support blocking and drainage gravel; do not block drain hole.
- D. Set hydrants plumb with pumper nozzle facing roadway; set hydrants with centerline of pumper nozzle 18 inches above finished grade and safety flange not more than 6 inches or less than 2 inches above grade.
- E. Paint hydrants in accordance with local color scheme.
- F. After hydrostatic testing, flush hydrants and check for proper drainage.

3.7 SERVICE CONNECTIONS

- A. Install water service where indicated on the Drawings or as directed by the Owner and/or Architect/Engineer.
- B. Provide water service as shown on the Drawings.
- C. Provide sleeve in retaining wall for service main. Support with reinforced concrete bridge. Calk enlarged sleeve watertight.
- D. Provide 18 gage, 0.0478 inch galvanized sheet metal sleeve surrounding service main to 6 inches above floor and 6 feet minimum below grade. Size for 2 inches minimum of glass fiber insulation stuffing.

3.8 PIPELINE MARKERS

- A. Underground Pipeline Markers
 - 1. Install continuously over top of pipe buried 6 inches below subgrade, above pipeline.
 - 2. Above Ground Pipeline Markers
 - a. Install pipeline markers adjacent to gate valves, butterfly valves, blow-off valves, and air release valves, per the manufacturer's recommendations.

3.9 CONCRETE THRUST RESTRAINT

- A. Provide valves, tees, bends, caps, and plugs with concrete thrust blocks as indicated on Drawings.
- B. Pour concrete thrust blocks against undisturbed earth. Locate thrust blocks at each elbow or change of pipe direction to resist resultant force and so pipe and fitting joints will be accessible for repair.
- C. Do not encase fitting joints and flanges.

3.10 TIED JOINT RESTRAINT

- A. Install tied joint restraint systems in accordance with Section 33 0519.
- B. Preparation
 - 1. Clean surfaces of pipe and fittings to receive tied joint restraint system.
- C. Installation
 - 1. Excavate and backfill in accordance with Section 31 2316.13 - Trenching.
 - 2. Install pipe and fittings in accordance with Section 33 3111 - Sanitary Utility Sewerage Piping.
 - 3. Install joint restraint system so joints are mechanically locked together to prevent joint separation.
- D. Erection Tolerances:
 - 1. Section 01 4000 - Quality Requirements: Tolerances.
 - 2. Torque nuts on mating threaded fasteners to 45 foot pounds to 60 foot pounds for 5/8-inch nut or per manufacturer's recommendations.
 - 3. Torque nuts on mating threaded fasteners to 75 foot pounds to 90 foot pounds for 3/4-inch nut or per manufacturer's recommendations.
 - 4. Torque 1 inch nuts to 100 foot pounds to 120 foot pounds or per manufacturer's recommendations.

3.11 DISINFECTION OF POTABLE WATER PIPING SYSTEM

- A. Flush and disinfect system in accordance with Section 33 1300.

3.12 FIELD QUALITY CONTROL

- A. Section 01 4000 - Quality Requirements: Requirements for inspecting, testing.
- B. Perform soil compaction tests in accordance with Section 31 2316.13.
- C. Perform pressure test on potable water distribution system in accordance with AWWA C600, AWWA C605, or as specified.

D. Test Pressure:

1. 1.5 x working pressure at test location elevation associated with the test section.
 - a. Do not exceed the rated pressure of pipe, fittings, valves, hydrants, and/or other related appurtenances.

E. Pressure/Leakage Test Procedure:

1. After completion of pipeline installation, including backfill, but prior to final connection to existing system, conduct concurrent pressure and leakage tests.

F. Provide equipment required to perform leakage and pressure tests. The meter utilized for testing shall have a low flow registration less than or equal to 0.03 gpm. The pressure gauge utilized for testing shall have a 4-inch dial or larger and gradation of 5 psi increments.

G. Conduct tests for at least two-hour duration.

H. No pipeline installation will be approved when pressure varies by more than 5 psi. Water shall be added to the test section to maintain the test pressure. The amount of water used shall be recorded.

I. Hydrostatic test boundaries shall be each valved section of water line. Each valve shall be subjected to test pressure on at least one side.

J. Before applying test pressure, properly fill, flush, and expel air from section of piping under test.

K. Slowly bring piping to test pressure and allow system to stabilize prior to conducting leakage test.

L. Examine exposed piping, fittings, valves, hydrants, and joints carefully during pressure test. Repair or replace damage or defective pipe, fittings, valves, hydrants, or joints discovered, following pressure test.

M. At the conclusion of the test, water shall be added to increase the pressure to the start test pressure. The amount of water added shall be recorded.

N. No pipeline installation will be approved when leakage is greater than that determined by the following formula:

$L = (SD \sqrt{P}) / C$
L = testing allowance in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches
P = average test pressure during hydrostatic test, in psig
C = 148,000
When pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

- O. When test of pipe indicates leakage greater than allowed, locate source of leakage, make corrections and retest until leakage is within allowable limits. Correct visible leaks regardless of quantity of leakage.

END OF SECTION

SECTION 33 1300 - DISINFECTING OF WATER UTILITY DISTRIBUTION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Disinfection of site water utility distribution piping specified in Section 33 1116.
- B. Disinfection of building domestic water piping specified in Section 22 1005.
- C. Testing and reporting results.

1.2 RELATED REQUIREMENTS

- A. Section 22 1005 - Plumbing Piping: Disinfection of building domestic water piping system.
- B. Section 33 1116 - Water Utility Distribution Piping.

1.3 REFERENCE STANDARDS

- A. AWWA B300 - Hypochlorites; American Water Works Association; 2010 (ANSI/AWWA B300).
- B. AWWA B301 - Liquid Chlorine; American Water Works Association; 2010 (ANSI/AWWA B301).
- C. AWWA B302 - Ammonium Sulfate; American Water Works Association; 2010 (ANSI/AWWA B302).
- D. AWWA B303 - Sodium Chlorite; American Water Works Association; 2013.
- E. AWWA C651 - Disinfecting Water Mains; American Water Works Association; 2014 (ANSI/AWWA C651-14).

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures and Section 01 7000 - Execution and Closeout Requirements for submittal requirements.
- B. Test Reports: Indicate results comparative to specified requirements.
- C. Certificate: From authority having jurisdiction indicating approval of water system.
- D. Certificate: Certify that cleanliness of water distribution system meets or exceeds specified requirements.
- E. Disinfection report:
 - 1. Type and form of disinfectant used.
 - 2. Date and time of disinfectant injection start and time of completion.
 - 3. Test locations.

4. Initial and 24 hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
5. Date and time of flushing start and completion.
6. Disinfectant residual after flushing in ppm for each outlet tested.

F. Bacteriological report:

1. Date issued, project name, and testing laboratory name, address, and telephone number.
2. Time and date of water sample collection.
3. Name of person collecting samples.
4. Test locations.
5. Initial and 24 hour disinfectant residuals in ppm for each outlet tested.
6. Coliform bacteria test results for each outlet tested.
7. Certification that water conforms, or fails to conform, to bacterial standards of authority having jurisdiction, suitable for human consumption.

1.5 QUALITY ASSURANCE

- A. Cleaning, disinfection and testing of water lines shall be the responsibility of the Contractor. Perform Work in accordance with AWWA C651-14.
- B. Water Treatment Firm: Company specializing in disinfecting potable water systems specified in this Section.
- C. Testing Firm: Company specializing in testing potable water systems, certified by governing authorities of the State in which the Project is located.
- D. Submit bacteriologist's signature and authority associated with testing.

PART 2 PRODUCTS

2.1 DISINFECTION CHEMICALS

- A. Chemicals: AWWA B300, Hypochlorite, AWWA B301, Liquid Chlorine, AWWA B302, Ammonium Sulfate, and AWWA B303, Sodium Chlorite.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01 3000 - Administrative Requirements for verification of existing conditions before starting Work.

- B. Verify that piping system has been cleaned, inspected, and pressure tested.
- C. Schedule disinfecting activity to coordinate with start-up, testing, adjusting and balancing, demonstration procedures, including related systems.

3.2 DISINFECTION

- A. Provide and attach equipment required to perform the Work.
- B. Perform disinfection of water distribution system.
- C. Introduce treatment into piping system.
- D. Maintain disinfectant in system for 24 hours minimum.
- E. Flush, circulate, and clean until required cleanliness is achieved; use municipal domestic water. The new system must be thoroughly flushed at a velocity of not less than 3.0 ft. per second until no trace of dirt or foreign matter is visible. Adequate provisions shall be made for drainage of flushing water. The sterilizing agent used must produce a solution of water and chlorine of not less than 25 mg/L available chlorine throughout the entire new piping system. Prior to flushing, the chlorine residual shall be measured. If it is less than 10 mg/L, the system shall be re-disinfected using 25 mg/L available chlorine in accordance with AWWA standards. After the chlorine solution has remained in the new piping system for at least 24 hours, the lines shall be thoroughly flushed until the normal residual chlorine in the system is measured.
- F. Replace permanent system devices removed for disinfection.

3.3 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 4000.
- B. Disinfection, Flushing, and Sampling:
 - 1. Notify Engineer, Owner, and testing agency 72 hours in advance of test and have witness test.
 - 2. Disinfect pipeline installation in accordance with AWWA C651. Use of liquid chlorine is not permitted.
 - 3. Upon completion of retention period required for disinfection, the treated water shall contain no less than 10 mg/L chlorine through the entire length of the main. Flush pipeline until chlorine concentration in water leaving pipeline is no higher than that generally prevailing in existing system or is acceptable for domestic use.
 - 4. Legally dispose of chlorinated water. When chlorinated discharge may cause damage to environment, apply neutralizing chemical to chlorinated water to neutralize chlorine residual remaining in water.
 - 5. After final flushing and before pipeline is connected to existing system, or placed in service, employ a State Health Department-approved independent testing laboratory to sample, test and certify water quality suitable for human consumption. A minimum of

two samples shall be collected from each sampling site for total coliform analysis. The number of sites depends on the amount of new construction but must include all dead end lines, be representative of the water in the newly constructed mains, and shall be collected a minimum of every 1,200 linear feet. These samples must be collected at least 16 hours apart and must show the water line to be absent of coliform bacteria.

6. If the membrane filter method of analysis is used for the coliform analysis, non-coliform growth must also be reported.
7. The chlorine residual must also be measured and reported.
8. All samples must be analyzed by a State certified laboratory.
9. Results of the bacterial examination shall be forwarded to the Engineer.
10. If laboratory results indicate the presence of coliform bacteria, the samples are unsatisfactory and disinfection shall be repeated until the samples are satisfactory. Cleaning, disinfection, and testing will be the responsibility of the Contractor. Water for these operations will be furnished by the Owner, but the Contractor shall include in the Bid the cost of loading, hauling, and discharging the water.
11. Testing and disinfection of the completed sections shall not relieve the Contractor of his responsibility to repair or replace any cracked or defective pipe. All work necessary to secure a tight line shall be performed at Contractor's expense.

END OF SECTION

SECTION 33 3111 - SANITARY UTILITY SEWERAGE PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Sanitary sewerage drainage piping, fittings, and accessories.
- B. Underground pipe markers.
- C. Connection of building sanitary drainage system to private sewer.
- D. Connection to existing manholes.
- E. Wye branches and tees.
- F. Sanitary laterals.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete for cleanout base pad construction.
- B. Section 31 2316 - Excavation: Excavating of trenches.
- C. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.
- D. Section 31 2323 - Fill: Bedding and backfilling.
- E. Section 33 0132 - Sewer and Manhole Testing.
- F. Section 33 0513 - Manholes and Structures.

1.3 REFERENCE STANDARDS

- A. ASTM International:
 - 1. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets; 2012.
 - 2. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings; 2014.
 - 3. ASTM C923 - Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Laterals; 2008 (Reapproved 2013).
 - 4. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings; 2004 (Reapproved 2011).
 - 5. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2012.
 - 6. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications; 2014.

7. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems; 2012.ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings; 2011.
 8. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings; 1996 (Reapproved 2010).ASTM D3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings; 2014.
 9. ASTM D3034 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2015.
 10. ASTM D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals; 2013.
 11. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Material; 2012.
 12. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe; 2014.
- B. Virginia Department of Health (VDH):
1. VDH Waterworks Regulations.
- C. Virginia Department of Environmental Quality (VDEQ):
1. Sewage Collection and Treatment Regulations.
- D. Virginia Department of Transportation (VDOT):
1. Road and Bridge Standards, 2016, published by VDOT.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Section 01 3000 - Administrative Requirements: Requirements for coordination.
- B. Coordinate Work with local sewerage authority.
- C. Notify affected utility companies minimum of 72 hours prior to construction.
- D. Coordination: Coordinate the installation with size, location and installation of service utilities.
- E. Preinstallation Meeting: Conduct a preinstallation meeting one month prior to the start of the work of this section; require attendance by all affected installers.
- F. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.
- G. Work in this Section includes all sanitary sewer work on this project.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures and Section 01 7000 - Execution and Closeout Requirements for submittal requirements.
- B. Product Data: Provide data indicating pipe, pipe accessories, and fittings.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.
- E. Field Quality Control Submittals: Document results of field quality control testing.
- F. Project Record Documents:
 - 1. Record location of pipe runs, connections, cleanouts, and invert elevations.
 - 2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 6000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. During loading, transporting and unloading, exercise care to prevent damage to materials.
- C. Do not drop pipe or fittings.
- D. Avoid shock or damage to pipe.
- E. Take measures to prevent damage to exterior surface or internal lining of pipe.
- F. Do not stack pipe higher than recommended by pipe manufacturer.
- G. Store gaskets for mechanical and push-on joints in cool, dry location out of direct sunlight and not in contact with petroleum products.
- H. Store polyvinyl chloride and polyethylene materials out of sunlight.

1.7 EXISTING CONDITIONS

- A. Verify field measurements and elevations are as indicated.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this Section.
- B. Installer: Company specializing in performing Work of this Section.

PART 2 PRODUCTS

2.1 SEWER PIPE AND FITTINGS

- A. Provide products that comply with applicable code(s).
- B. PVC Flexible Joint Plastic Pipe: ASTM D3034, Type PSM, Poly (Vinyl Chloride) (PVC) material; bell and spigot style rubber ring sealed gasket joint.
 - 1. Pipe Class: SDR 35.
 - 2. Minimum Pipe Stiffness: 46 psi.
 - 3. Fittings: PVC conforming to pipe specifications.
 - 4. Joints: ASTM D3212, elastomeric gaskets.
 - 5. Rubber Gaskets: Meet requirements of ASTM F477 or ASTM D1869.
- C. PVC Pipe AWWA C900
 - 1. Pipe Class: DR 14, 305 psi.
 - 2. Fittings: Ductile Iron, Mechanical Joint, AWWA C110.
 - 3. Joints: PVC, ASTM D3139 with ASTM F477 PVC, flexible elastomeric seals. Solvent cement couplings are not permitted.

2.2 FLEXIBLE PIPE TO MANHOLE CONNECTION

- A. Manufacturers:
 - 1. National Pollution Control Systems, Inc.
 - 2. Press-Seal Gasket Corporation.
 - 3. Interpace Corporation.
 - 4. Substitutions: Equal per Section 01 6000 - Product Requirements.
- B. Pipe to manhole connection shall be sealed with a flexible boot, gasket, sleeve, or as detailed on Drawings.
 - 1. When the boot is used, the port shall be cored to the size, shape, surface finish, and location required and not cast in the manhole. The boot shall consist of a rubber gasket, an internal expansion sleeve, and one or more external compression take-up clamps.
 - 2. When gasket is used, the gasket shall be a rubber-pressed wedge gasket cast into the manhole.
 - 3. When sleeve is used, the sleeve shall be a flexible rubber sleeve cast into the manhole complete with stainless steel strap.
 - 4. All field penetrations into manholes shall be cast-in-place, cored, or saw cut to a sufficient size to accommodate the seals referenced above.
- C. Materials:

1. Gaskets, Expansion Sleeves, and Connectors: Natural or synthetic rubber meeting ASTM C923.
2. Clamps and Hardware: Series 300 non-magnetic stainless steel.

2.3 UNDERGROUND PIPE MARKERS

- A. Plastic Ribbon Tape: Metallic core, brightly colored green continuously printed with "GRAVITY SEWER" in large letters, minimum 6 inches wide by 4 mils thick.

2.4 MANHOLES

- A. Manholes: As specified in Section 33 0513 and indicated on Drawings; cover inscribed with "SANITARY SEWER".

2.5 BEDDING AND COVER MATERIALS

- A. Pipe Bedding Material: As specified in Section 31 2316.13.
- B. Pipe Cover Material: As specified in Section 31 2316.13.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01 7000 - Execution and Closeout Requirements: Verification of existing conditions before starting Work.
- B. Verify existing sanitary sewer utility main size, location, and inverts are as indicated on Drawings.

3.2 EXCAVATION AND BEDDING

- A. Excavate pipe trench in accordance with Section 31 2316.13.
- B. Excavate to lines and grades shown on Drawings or required to accommodate installation of encasement.
- C. Dewater excavations to maintain dry conditions and preserve final grades at bottom of excavation.
- D. Provide sheeting and shoring in accordance with Section 31 2316.13.
- E. Place bedding material and backfill trench per Section 31 2316.13.

3.3 INSTALLATION - PIPE

- A. Install in accordance with manufactures instructions and as indicated on Drawings.
- B. Install plastic pipe, fittings, and accessories in accordance with ASTM D2321.
- C. Seal joints watertight.

- D. Lay pipe to slope gradients indicated on Drawings. Begin at downstream end and progress upstream
- E. Ensure entire pipe is supported by bedding.
- F. Assemble and handle pipe in accordance with manufacturer's instructions except as modified on the Drawings or by Engineer.
- G. Keep pipe and fittings clean until work is completed and accepted by Engineer. Cap open ends during periods of work stoppage.
- H. Lay bell and spigot pipe with bells upstream.
- I. Pipe Joint. Preparatory to making pipe joints on gravity sewer lines, clean and dry all surfaces of joint pipe and jointing material. Use lubricants, primers, adhesives, and similar materials as recommended by the manufacturers. Place, fit, join, and adjust the jointing materials or factory fabricated joints as recommended by the manufacturer to obtain the degree of water tightness required. As soon as possible after the joint is made, place sufficient backfill material along each side of the pipe to resist forces that might tend to move the pipe off line and grade.
 - 1. Place backfill over the pipe immediately after the pipe has been laid.
- J. Join Push-On Joint Pipe as Follows:
 - 1. Thoroughly clean inside of the bell and 8 inches of the outside of the spigot end of the joining pipe to remove oil, grit, excess coating, and other foreign matter. Flex rubber gasket and insert in the gasket recess of the bell socket. Apply a thin film of gasket lubricant supplied by pipe manufacturer to either the gasket or the spigot end of the joining pipe.
 - 2. Start spigot end of pipe into socket with care. The joint shall then be completed by forcing the plain end to the bottom of the socket with a forked tool or jack type device. Field-cut pipe shall have the end filed to match the manufactured spigot end.
 - 3. Permissible deflection of push-on joint pipe in force mains shall not be greater than listed in AWWA C600.
- K. Join polyvinyl chloride (PVC) pipe as recommended by the manufacturer using rubber ring gaskets in bell ends.
- L. Connect pipe to existing sewer system as indicated on Drawings at existing manhole or using doghouse manhole connection per Section 33 0513.
- M. Place haunching material, rod, and tamp per Section 31 2316.13 to eliminate voids.
- N. Install underground marking tape continuously 18 inches above pipeline.
- O. Parallel Installation:

1. Normal Conditions: Sewer lines and manholes shall be constructed at least 10 feet horizontally from a water line whenever possible. The distance shall be measured edge to edge.
2. Unusual Conditions: When local conditions prevent a horizontal separation of at least 10 feet, the water line may be laid closer to a sewer or sewer manhole provided that:
 - a. The bottom of the water line is at least 18 inches above the top of the sewer.
 - b. Where this vertical separation cannot be obtained, the sewer shall be constructed of AWWA-approved water pipe pressure-tested in place to 50 psi without leakage prior to backfilling. The sewer manhole shall be of watertight construction and tested in place.

P. Crossing:

1. Normal Conditions: Sewers crossing under water lines shall be laid to provide a separation of at least 18 inches between the bottom of the water line and the top of the sewer whenever possible.
2. Unusual Conditions: When local conditions prevent a vertical separation described in the paragraph above, the following construction shall be used:
 - a. Sewers passing over or under water lines shall be constructed as described in Parallel Installation, Unusual Conditions above.
 - b. Sewer passing over water lines shall be laid to provide:
 - 1) Vertical separation of at least 18 inches between bottom of sewer and top of water line.
 - 2) Adequate structural supports for the sewers to prevent excessive deflection of the joints and settling on and breaking water line.
 - 3) Maximum separation of water and sewer line joints.

3.4 CONNECTION TO EXISTING MANHOLE

- A. Core drill or saw cut existing manhole to clean opening. Use of pneumatic hammers, chipping guns, and sledgehammers is not permitted.
- B. Install flexible pipe to manhole connector and seal with non-shrink concrete grout.
- C. Concrete encase new sewer pipe minimum of 24 inches to nearest pipe joint. Use epoxy binder between new and existing concrete.
- D. Prevent construction debris from entering existing sewer line when making connection.

3.5 INSTALLATION - MANHOLE

- A. Install manholes in accordance with Section 33 0513.

3.6 BACKFILLING

- A. Backfill around sides and to top of pipe in accordance with Section 31 2316.13.
- B. Maintain optimum moisture content of backfill material to attain required compaction density.

3.7 FIELD QUALITY CONTROL

- A. Section 01 4000 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Request inspection prior to and immediately after placing bedding.
- C. Perform test on sanitary sewage system in accordance with Section 33 0132 and local code.
- D. Compaction Testing: In accordance with Section 31 2316.13.
- E. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

3.8 PROTECTION OF FINISHED WORK

- A. Section 01 7000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.
- C. Place backfill over the pipe immediately after the pipe has been laid.

END OF SECTION

SECTION 33 4111 - STORM UTILITY DRAINAGE PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Storm drainage piping, fittings, and accessories.
- B. Connection of drainage system to municipal sewers.
- C. Catch basins, Paved area drainage, Site surface drainage, and Cleanouts, manholes and structures.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000: Concrete for cleanout base pad construction.
- B. Section 31 2316: Excavating of trenches.
- C. Section 31 2316.13: Excavating, bedding, and backfilling.
- D. Section 31 2323: Bedding and backfilling.
- E. Section 33 0513 - Manholes and Structures.

1.3 REFERENCE STANDARDS

- A. 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines; current edition.
- B. AASHTO M 252 - Standard Specification for Corrugated Polyethylene Drainage Pipe; 2009.
- C. AASHTO M 294 - Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500 MM (12- to 60- in.) Diameter; 2013.
- D. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design; 2010.
- E. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings; 2013a.
- F. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2015.
- G. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications; 2014.
- H. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings; 2011.
- I. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Material; 2014.
- J. DIN EN 1433 - Drainage Channels for Vehicular and Pedestrian Areas - Classification, Design and Testing Requirements; Marking and Evaluation of Conformity; 2005.

- K. DIN 19580 - Drainage Channels for Vehicular and Pedestrian Areas - Durability, Mass per Unit Area and Evaluation of Conformity; 2010.
- L. Virginia Department of Transportation (VDOT):
 - 1. Road and Bridge Specifications, 2020, published by VDOT.
 - 2. Road and Bridge Standards, 2016, published by VDOT.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. See Section 01 7000 - Execution and Closeout Requirements, for coordination and project conditions.
- B. Coordination: Coordinate the installation of with size, location and installation of service utilities.
- C. Notify affected utility companies a minimum of 72 hours prior to construction.
- D. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures and Section 01 7000 - Execution and Closeout Requirements for submittal requirements.
- B. Product Data: Provide data indicating pipe, pipe accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.
- E. Field Quality Control Submittals: Document results of field quality control testing.
- F. Project Record Documents:
 - 1. Record location of pipe runs, connections, catch basins, cleanouts, and invert elevations.
 - 2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with VDOT Road and Bridge Specifications.
- B. Maintain one copy of document on site.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section.

- B. Installer: Company specializing in performing Work of this Section.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. See Section 01 6000 - Product Requirements for requirements for transporting, handling, storing, and protecting products.
- B. Block individual and stockpiled pipe lengths to prevent moving.
- C. Do not place pipe or pipe materials on private property or in areas obstructing pedestrian or vehicle traffic.
- D. Do not place pipe flat on ground. Cradle to prevent point stress.
- E. Store UV sensitive materials out of direct sunlight.

PART 2 PRODUCTS

2.1 SEWER PIPE MATERIALS

- A. Provide products that comply with applicable code(s).
- B. Plastic Pipe: ASTM D1785, Schedule 40, Poly Vinyl Chloride (PVC) material; inside nominal diameter of 4-6 inches, bell and spigot style solvent sealed joint end.
- C. Plastic Pipe: ASTM D3350, High Density Polyethylene (HDPE) corrugated wall pipe with integrally formed smooth liner; meeting the requirements of AASHTO M 252, Type S, for diameters between 3 inches and 10 inches and AASHTO M 294, Type S, for diameters between 12 inches and 60 inches, soil-tight, bell and spigot joints with rubber gaskets, with pipe and fittings manufactured from virgin PE compounds with cell classification 3254420C.

2.2 PIPE ACCESSORIES

- A. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tee, bends, elbows, cleanouts, reducers, traps and other configurations required.
- B. Filter Fabric: Non-biodegradable, non-woven.

2.3 CATCH BASIN, CLEANOUT, AND AREA DRAIN COMPONENTS

- A. Lids and Drain Covers: Cast iron, hinged to cast iron frame.
 - 1. Catch Basin: Refer to Drawings.
 - 2. Cleanout: Refer to Drawings.
 - 3. Area Drain: Refer to Drawings.

2.4 MANHOLES AND STRUCTURES

- A. Manholes: As indicated on Drawings; covers inscribed "STORM SEWER".
- B. Catch Basin, Inlets, and Junction Boxes: Indicated on Drawings.

2.5 BEDDING AND COVER MATERIALS

- A. General: Conform to Section 31 2316.13 - Trenching and Section 31 2323 - Fill for bedding and backfill around and on top of pipe.
- B. Bedding for Flexible Pipe (HDPE and CMP): Aggregate fill; shall meet VDOT requirements for No. 25 or No. 26 crusher run aggregate or No. 57 coarse aggregate.

PART 3 EXECUTION

3.1 EXAMINATION

- A. See Section 01 7000 - Execution and Closeout Requirements for verification of existing conditions before starting work.
- B. Verify trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on Drawings.

3.2 TRENCHING

- A. See Section 31 2316.13 for additional requirements.
- B. Hand trim excavation for accurate placement of pipe to elevations indicated.
- C. Excavate to lines and grades shown on Drawings or to accommodate installation of encasement.
- D. Dewater excavations to maintain dry conditions and preserve final grades at bottom of excavation.
- E. Provide sheeting and shoring in accordance with Section 31 2316.13.
- F. Place bedding material at trench bottom, level continuous layer not exceeding 8 inches compacted depth; compact to 95 percent per Section 31 2316.13.
- G. Maintain optimum moisture content of bedding material to attain required compaction density.
- H. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.3 INSTALLATION - PIPE

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings.
- B. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on the drawings.
- C. Install pipe, fittings, and accessories in accordance with manufacturer's instructions and as indicated on Drawings. Seal watertight.

1. Plastic Pipe: Also comply with ASTM D2321.
- D. Lay pipe to slope gradients noted on the drawings; with maximum variation from true slope of 1/8 inch in 10 feet. Begin at downstream end and progress upstream.
- E. Connect to building storm drainage system, foundation drainage system, and utility/municipal sewer system.
- F. Make connections through walls through sleeved openings, where provided.
- G. Seal joints watertight.
- H. Keep pipe and fittings clean until Work is completed and accepted by Engineer. Cap open ends during period of work stoppage.
- I. Lay bell and spigot pipe with bells upstream.
- J. Connect pipe to existing sewer system as indicated on Drawings at existing manhole or doghouse manhole connection per Section 33 0513.

3.4 INSTALLATION - MANHOLES, CATCH BASINS, AND CLEANOUTS

- A. Install manholes in accordance with Section 33 0513.
- B. Form bottom of excavation clean and smooth to correct elevation.
- C. Form and place cast-in-place concrete base pad, with provision for sanitary sewer pipe end sections.
- D. Level top surface of base pad; sleeve concrete shaft sections to receive storm sewer pipe sections.
- E. Establish elevations and pipe inverts for inlets and outlets as indicated.
- F. Mount lid and frame level in grout, secured to top cone section to elevation indicated.
- G. Prefabricated trench drains:
 1. Excavate; prepare substrate and supports according to the manufacturer's printed installation instructions.
 2. Install prefabricated trench drain system according to the manufacturer's printed installation instructions.
 3. Expansion, Construction, and Control Joints: Do not locate trench drain system on an expansion, construction or control joint in concrete or pavement. Where concrete or pavement joints running transverse to direction of flow cross the trench drain system, locate concrete or pavement joints and trench drain system joints so that both coincide.
 4. Concrete Trench Support: 3000 pounds per square inch compressive strength, minimum.

- a. Provide support on all sides of trench in minimum thickness recommended by trench drain system manufacturer.
- b. Screed and finish top edge of concrete flush with top surface of trench drain system.
- c. Do not use secondary edge finishing tools.

3.5 INSTALLATION - CONNECTION TO EXISTING STRUCTURES

- A. Core drill existing manhole to clean opening. Do not use pneumatic hammers, chipping guns, or sledgehammers.
- B. Install watertight neoprene gasket and seal with non-shrink concrete grout.
- C. Concrete encase new sewer pipe minimum of 24 inches to nearest pipe joint. Use epoxy binder between new and existing concrete.
- D. Prevent construction debris from entering existing sewer line when making connection.

3.6 FIELD QUALITY CONTROL

- A. Perform field inspection in accordance with Section 01 4000.
- B. Request inspection prior to and immediately after placing aggregate cover over pipe.
- C. Soil Compaction Testing: In accordance with 31 2316.13.
- D. When tests indicate work does not meet specified requirements, remove work, replace and retest.

3.7 PROTECTION

- A. Section 01 7000 - Execution and Closeout Requirements: Protecting finished Work.
- B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.
 - 1. Take care not to damage or displace installed pipe and joints during construction of pipe supports, backfilling, testing, and other operations.
 - 2. Repair or replace pipe that is damaged or displaced from construction operations.

END OF SECTION

APPENDICES

APPENDIX A

Geotechnical Engineering Report, dated April 14, 2023 & Revised May 10, 2023

GEOTECHNICAL ENGINEERING REPORT

Montgomery County Magistrate and Court Services Building Christiansburg, Virginia

Schnabel Reference #22160136.000

April 14, 2023

Revised May 10, 2023

April 14, 2023
Revised May 10, 2023

Mr. Scott Woodrum, PE
County Engineer/Director of General Services
Montgomery County, Virginia
755 Roanoke Street, Suite 1C
Christiansburg, Virginia 24073

**Subject: Geotechnical Engineering Report, Montgomery County Magistrate
and Court Services Building, Christiansburg, Virginia (Schnabel
Reference 22160136.000)**

Dear Scott:

SCHNABEL ENGINEERING, LLC is pleased to submit our revised geotechnical engineering report for this project. This study was performed in accordance with our revised proposal dated February 13, 2023, as authorized by Purchase Order 20233498 dated February 16, 2023. This revision includes laboratory test data and associated commentary that was not available on the original submittal date.

SCOPE OF SERVICES

Our revised proposal dated February 13, 2023 defines the scope of services for this project. The scope of services included subsurface exploration, field engineering, and laboratory testing. We used this information and subsequent analyses to develop this report, including the following scope items:

- Estimated subsurface conditions and groundwater levels within the area explored based on data collected in the subsurface exploration.
- Foundation recommendations for spread footings including a net allowable soil bearing pressure, bearing grades, estimated settlements, minimum dimensions, and frost depth.
- Recommended Seismic Site Class and Seismic Site Coefficients (F_a and F_v) in accordance with Virginia Construction Code 2018 for use in foundation design based on an extrapolation of data collected in the subsurface exploration.
- Evaluation of the shrink/swell potential of the soils encountered in the exploration.
- Review of geologic information to evaluate the potential for sinkhole development on the site.
- Recommendations for site development in karst terrain.
- Recommendations for floor slab support, including a recommended modulus of subgrade reaction for use in slab design and capillary moisture barrier recommendations.
- Earthwork recommendations for construction of load-bearing fill including an assessment of on-site soils for use as fill, subgrade preparation, and compaction criteria.

Montgomery County, Virginia
Montgomery County Magistrate and Court Services Building

- Recommended asphaltic concrete pavement sections based on CBR Bearing Ratio (CBR) data and traffic loading to be provided to us by others.
- Recommended static earth pressures, subdrainage, and backfill requirements for interior building walls below grade and site retaining walls.
- Comments on the corrosion potential of the on-site soils
- Construction considerations related to the implementation of our recommendations.

PROJECT DESCRIPTION

Site Description

The site is located on the campus of the existing Montgomery County Jail, Courthouse, and Public Safety Building between East Main and First Streets in downtown Christiansburg, Virginia. The proposed site comprises the existing parking lot and two buildings (the existing Old Sheriff's Office and Old 911 Call Center buildings) along South Franklin Street that are slated for demolition. Existing site grades generally slope down from southeast to northwest and vary from about El 2104 to El 2094 within the proposed building footprint.

Schnabel obtained the site information from the topographic site plan prepared by Thompson & Litton, Inc., and through our site visits. A Site Vicinity Map is included as Figure 1.

Proposed Construction

Montgomery County intends to develop this site for a new Magistrate and Court Services building. The proposed one-story structure will be situated near the south corner of the existing parking lot along First Street. To accommodate the existing sloping grades, the building is expected to have split floor levels. The high floor grade will be at the southeast end of the site and the lower floor grade will start about mid-way through the building and be 5.3 ft lower. Construction will likely consist of structural load bearing block walls with brick façade and a concrete slab-on-grade. A Salley port will be included at the northwest end of the magistrate portion of the proposed building, adjacent to the existing jail building. As previously mentioned, the existing Old Sheriff's Office and Old 911 Call Center buildings along South Franklin Street will be demolished as part of this project to provide additional space for paved parking. Thompson & Litton, Inc. (T&L) is providing design services.

We based this description of the proposed construction on a Preliminary Site plan prepared by T&L and our conversations with T&L personnel.

Regional Geology

Christiansburg is located within the Appalachian Valley and Ridge Province of Virginia. The exposed rocks of the area consist of Cambrian and Ordovician age carbonate rocks. The major structural feature of the area is the Pulaski Thrust Sheet. The Pulaski Thrust Sheet consists of intensely deformed Cambrian age dolomite, limestone, and shale of the Elbrook and Rome formations, which have been thrust over younger Mississippian age clastic rocks. The Elbrook and Rome formations in the Christiansburg area are complexly folded, faulted, and fractured, and contain localized pockets of breccia.

Residual silt and clay soils typically overlie these rocks, with alluvial deposits located in the stream valleys. Man-made fill deposits from past site grading and development are scattered across the area.

Subsurface Exploration and Laboratory Testing Program

We performed a subsurface exploration consisting of test borings to identify the subsurface stratigraphy underlying the site and to evaluate the geotechnical properties of the materials encountered. Exploration methods used are discussed below. The appendices contain the results of our exploration.

Subsurface Exploration Methods

Schnabel's subcontractor, Blue Ridge Drilling, Inc. drilled 11 test borings and two offset borings at this site under our observation on March 1 and 2, 2023. The Standard Penetration Test (SPT) was performed at selected depths in the borings. Appendix A includes specific observations, remarks, and logs for the borings; classification criteria; drilling methods; and sampling protocols. Figure 2 (included at the end of this report) indicates the approximate test boring locations. We will retain soil samples up to 45 days beyond the issuance of this report, unless you request other disposition.

The SPT samples were obtained using a hydraulically driven automatic trip hammer (ATH). Most correlations with SPT data are based on N-values collected with a safety hammer. The energy applied to the split-spoon sampler using the ATH is about 30 percent greater than that applied using the safety hammer, resulting in lower N-values. The hammer blows shown on the boring logs are uncorrected for the higher energy. However, we correct SPT N-values for the higher energy when using N-values in our analyses.

Soil Laboratory Testing

Our laboratory performed tests on selected samples collected during the subsurface exploration. The testing aided in the classification of materials encountered in the subsurface exploration and provided data for use in the development of recommendations for design of foundations, earthwork, and pavements. The results of the laboratory tests are included in Appendix B and are summarized for each stratum in the *Subsurface Conditions* section of this report. Selected test results are also shown on the boring logs in Appendix A.

Index Testing

We performed index testing on samples collected as part of the exploration to provide soil classifications and to provide parameters for use with published correlations with soil properties. Index testing included performing natural moisture content, Atterberg Limits, and gradation tests on tube and bulk samples of soil representing Strata A and B soils.

Consolidation Testing

We performed one-dimensional consolidation testing (ASTM D2435) on an intact soil specimen trimmed from a tube sample collected in Boring B-04. The results of the consolidation testing are summarized in Table 1 below and are also included in Appendix B.

Table-1 Site-Specific Consolidation Test Results

Boring	Depth (ft)	Stratum	USCS	Recompression Ratio, $C_{\epsilon r}$	Compression Ratio, $C_{\epsilon c}$	Probable Preconsolidation Pressure, P_p (tsf)
B-07A	10-12	B	CH	0.010	0.153	6.0

Compaction and California Bearing Ratio (CBR) Testing

We performed Standard Proctor compaction and CBR testing to evaluate compaction characteristics and to provide soil parameters for pavement design. Testing was performed on two samples representing Strata A and B. Reported CBR values represent the 0.1 inch penetration value corrected for concavity, as applicable. Table 2 summarizes the compaction and CBR testing results.

Table 2: Soil Compaction and CBR Test Results

Boring Number	Depth (ft)	USCS Classification	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	CBR Value (0.1", Soaked)	CBR Swell (%)
B-06	1-10	CH	99.1	23.6	5.8	0.6
B-09	0.5-10	CH	95.4	25.9	5.4	0.7

The CBR test results and soil classification test results for the samples recovered from Borings B-06 and B-09 indicate these soils exhibit a moderate to high potential for moisture-related volume change (shrink/swell behavior).

Chemical Testing

We performed a series of corrosion potential tests on soil samples recovered from Borings B-07A and B-09. The series consists of natural moisture content, resistivity, pH, sulfides content, and oxidation-reduction potential tests. The primary function of the corrosion potential series of tests is to evaluate whether the existing soil environment might affect the corrosion rate of gray and ductile cast iron pipe. The corrosion potential was evaluated based on a point system in which points are assigned to the soil based on the values from each of the five tests. If the points total ten or more for the five tests, the soil is considered to be corrosive and, therefore, protection of the pipes is necessary.

Based on the laboratory test results, the on-site soils do not appear to be corrosive to gray and ductile iron pipe. The point total for the series from Boring B-07A was five and the series from Boring B-09 was eight, with ten or more being corrosive. Based on the trace to neutral results obtained from the sulfides content tests, we also do not expect that the soils will be corrosive to concrete. Test results are presented below in Table 3 and are also included in Appendix B.

Table-3 Site-Specific Chemical Test Results

Boring	Depth (ft)	Stratum	USCS	pH	Resistivity (ohm-cm)	Redox Potential	Sulfide Content ⁽¹⁾ (ppm)
B-07A	10-12	B	CH	5.2	1200	357	<10
B-09	1-10	A/B	CH	7.1	900	254	<10

Note 1: Detectable limit of sulfide content is 10 ppm, "<10" indicates ion content not detected during testing.

SUBSURFACE CONDITIONS

Generalized Subsurface Stratigraphy

We characterized the following generalized subsurface stratigraphy based on the exploration and laboratory test data included in the appendices.

Surface Cover

We encountered topsoil at the ground surface to a depth of about 1 inch in Boring B-11. All of the other borings were drilled through the existing asphaltic pavement. We observed between 1 and 4 inches of asphalt underlain by a layer of dense graded aggregate ranging in thickness from 4 to 14 inches.

Stratum A: Fill Soils

We encountered existing fill soils associated with past site grading activities in all of the borings to depths ranging from 4 ft to 7 ft beneath the existing ground surface. The existing fill soils of Stratum A are composed primarily of fine-grained soils classifying as lean clay, fat clay, and elastic silt, with varying amounts of sand and gravel. The Stratum A soils were generally firm to very stiff in consistency based on Standard Penetration Test N-values ranging from 6 to 20. Natural moisture contents of Stratum A soils tested ranged from 15.2 to 41.8 percent.

Stratum B: Residual Soils

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. We encountered residual soils in all the borings beneath Stratum A fill to depths of 9 to 20 ft, the maximum depth explored in the borings. The residual soils encountered typically consist of fine-grained cohesive soils classifying as LEAN CLAY (CL) and FAT CLAY (CH), with varying amounts of sand and gravel. We also encountered a layer of coarse-grained residual soil in Boring B-1A, which we visually classify as dense SILTY GRAVEL (GM). An N-value of 37 was recorded in this layer. The fine-grained soils were generally soft to very stiff consistency based on N-values ranging from 2 to 21.

Laboratory testing conducted on samples of residuum indicated insitu moisture contents ranging from 8.2 to 49.8 percent. Classification (Atterberg Limits and gradation) testing performed on two bulk samples of residuum resulted in Liquid Limit values of 72 and 76 and Plasticity Indices of 46 for both samples. We recorded 82.2 and 93.2 percent material by weight finer than the No. 200 sieve. Stratum B soils are predominantly high plasticity silts and clays with a moderate to high potential for volume change

(shrink/swell). Based on the consolidation test results, the sample of Stratum B soil tested was highly overconsolidated with an Overconsolidation Ratio (OCR) of about 10.

Stratum C: Disintegrated Rock

Disintegrated rock is defined as residual material with SPT N-values between 60 blows per foot and refusal. Sampler refusal is defined as an N-value of 50 blows for a penetration of 1 inch or less. We encountered disintegrated rock at depths ranging from 4.0 ft to 19.5 ft in Borings B-01, B-01A, B-02, B-05, B-06, and B-08. We classified the disintegrated rock as very dense SILTY SAND (SM), SILTY GRAVEL (GM), and SANDY SILT (ML). N-values in Stratum C ranged from 50/6" to 50/2". We recorded auger refusal on rock at depths ranging from 5.5 and 12.5 ft in these borings. A summary of depths to and elevations of disintegrated rock and auger refusal elevations is presented in Table 4.

Table 4: Disintegrated Rock (DR) and Refusal Elevation

Boring Number	Depth to DR (ft)	DR Elevation	Depth of Auger Refusal (ft)	Auger Refusal Elevation
B-01	4.0	2097.0	5.5	2095.5
B-01A	9.0	2092.0	9.5	2091.5
B-02	19.0	2083.0	19.3	2082.7
B-04	NA	NA	12.5	2083.5
B-05	18.5	2075.5	NA	NA
B-06	19.5	2073.5	19.8	2073.2
B-08	13.0	2083.0	15.0	2081.0

Groundwater

We encountered groundwater during drilling in Borings B-06 and B-10 at depths of 17.3 ft and 6.0 ft (EL 2075.7 and 2092.0 ft), respectively. Upon completion of drilling, the groundwater level in B-10 was measured to be 5.7 ft, EL 2092.3 ft, whereas B-06 caved dry to 5.7 ft below the ground surface. The remaining borings caved dry at depths between 1.0 and 8.3 ft below the ground surface. The test boring logs in Appendix A include groundwater observations obtained during our subsurface exploration. These data include depths to groundwater encountered during drilling, upon drilling completion, and following completion of the boring.

The groundwater levels on the logs indicate our estimate of the hydrostatic water table at the time of our subsurface exploration. The final design should anticipate the fluctuation of the hydrostatic water table depending on variations in precipitation, surface runoff, pumping, evaporation, leaking utilities, and similar factors.

Seismic Site Classification

We evaluated the Seismic Site Class and Seismic Site Coefficients for this project according to the International Building Code (IBC) Section 1613 (2018). Our analysis indicates Site Class C and Seismic Site Coefficients of $F_a = 1.2$ and $F_v = 1.7$ for the proposed structure. This Site Class was evaluated based on corrected SPT N-values.

GEOTECHNICAL RECOMMENDATIONS

We based our geotechnical engineering analysis on the information developed from our subsurface exploration and soil laboratory testing, along with the preliminary site plan provided by your office. We recommend shallow spread footings for support of the proposed building based on our analysis. The following sections of the report provide our detailed recommendations.

Karst Discussion

The term karst is widely used to describe terrain produced by ground subsidence associated with the dissolution of carbonate rocks. Many karst regions of the world have their distinctive characteristics. The study area is situated in the Appalachian Valley karst region. Characteristics of the Appalachian Valley karst include sinkholes, sinking streams, underground drainage, caves, highly variable bedrock surface with pinnacles/ledges and troughs, exposed expanses of solution-etched bedrock called karren, linear ledges of bedrock, and high plasticity residual soils. Sinkholes are closed contour depressions formed by subsidence or collapse of soil overburden or bedrock caused by dissolution of the underlying bedrock.

As carbonate rock dissolves, the soluble minerals are carried away by the groundwater, leaving behind the insoluble materials (clay minerals and silicates). The process reduces hard rock into soft soil with the consistency of paste. The rate of rock dissolution is rapid relative to geologic time, but very slow on a human time scale, at only about 2 to 4 mm per century in the eastern United States (Sowers, 1996). Rock dissolution occurs primarily from the surface downward, and along the surfaces of fissures (joints, bedding planes and fractures) in the rock. The rock fissures are enlarged, creating soil filled troughs and channels surrounded by hard rock. The soil filling is often eroded by flowing groundwater and the troughs and channels become open cavities. These cavities can develop and become interconnected to form caves, which are open conduits for groundwater flow and sediment transport.

As a cavity in the rock grows and expands, the tensile stresses in the roof of the cavity increase, and occasionally the roof will spall slabs of rock, causing the cavity to grow upward toward the ground surface. When a cavity in the rock grows to the point that the roof of rock is too thin or too weak to span the void and support the overburden, the cavity can collapse and form a sinkhole at the ground surface. This type of sinkhole development is a relatively rare occurrence because it is a slow process in terms of human time.

The more common mechanism for sinkhole development is through the erosion of soil overburden into cavities in the underlying rock. This erosion starts at the soil-rock interface over an opening in the bedrock. As soil is carried into the opening by percolating groundwater, a cavity is formed in the soil. This cavity grows as the result of raveling of soil from the roof, and can eventually collapse to the surface, causing a sinkhole. This collapse can be caused by the soil overburden weight, new structural loads, vibrations, construction equipment weight and changes in the groundwater levels. Subsurface soil erosion is aggravated by the following hydrologic factors: 1) increasing the infiltration of water at the ground surface; 2) lowering of the groundwater level so as to increase the vertical flow gradient and erosion potential at the critical soil-rock interface; and 3) alternately draining and saturating the soil at the critical soil-rock interface by repeatedly fluctuating the groundwater level from above to below the interface.

Non-carbonate rocks, such as sandstone, granite and schist, weather through chemical and mechanical mechanisms, and leave behind residual soil overburden that decreases in density and hardness with distance from the parent rock. Carbonate rocks, on the other hand, weather predominantly through dissolution, a process that removes a portion of the rock mass and leaves behind only the insoluble material which occupies less volume than the parent rock and as such lacks stiffness, density and structure. Therefore, the soils adjacent to the rock surface can be soft and paste-like. These soils gain strength over time through the processes of desiccation and consolidation. As discussed previously, carbonate rocks dissolve along joints and fissures, leaving a rock surface that is erratic, with pinnacles of rock cut by soil-filled troughs. Between the pinnacles, soil desiccation and consolidation are inhibited and the soil remains soft and paste-like.

At this site, we did not observe any sinkholes and, according to published sinkhole mapping, there are no sinkholes in the immediate vicinity of the site. Additionally, we did not encounter voids within the residual soil stratum in any of the borings, though there was a zone of soft soil in Boring B-03 between the depths of 4 and 6 ft, approximate El 2096 to El 2094.0. Based on our observations at the site and in the borings, we consider the potential for sinkhole development at this site to be relatively low. However, it will still be important to control surface water runoff and to prevent concentrated infiltration of water into the ground.

Engineering and Development Implications of Karst

The impact of karst conditions on structures can generally be referred to as “subsidence”, which can be separated into three primary problems: differential settlement of structures due to an irregular bedrock surface blanketed by soft soils; subsurface erosion of soil leading to gradual surface settlement; and sudden collapse of soil or rock cavities leading to rapid loss of structural support.

We have qualitatively evaluated the subsidence risk at the site based on a number of factors, including frequency of sinkholes in the area, geology, groundwater conditions, subsurface drilling data, site reconnaissance, and future development impacts. We did not observe evidence of surface subsidence during our site visit and soils encountered in the borings was generally firm to very stiff.

There will always be some risk of future sinkhole development. By taking precautions during design and construction, the probability of future sinkhole development can be greatly reduced. Final design plans should incorporate measures that will inhibit surface water infiltration, such as providing water-tight storm drains, roof drains that tie directly into the storm drainage system, and utilities that do not run along building lines. Stormwater infiltration practices are not appropriate for this site because of the risk of causing subsurface erosion and sinkhole development.

Site Grading and Earthwork

As of this writing, grading plans have not yet been finalized for this project. Based on the site topography shown on the available plans, we estimate that up to about 3 to 5 ft of cut and fill may be required to grade the building pad and surrounding driveway areas. Rock could be encountered in deeper cuts and utility excavations. Rock beneath this site is hard and we anticipate that it will require rock excavation techniques to remove. Recommendations for compacted fill subgrade preparation, fill soil requirements, placement guidelines, evaluating rock excavation, and compaction criteria are presented in subsequent sections.

Compacted Fill Subgrades

Subgrades to receive compacted structural fill for building, retaining wall, and pavement support should be stripped of existing asphalt pavements, vegetation, topsoil, and organic matter. Schnabel's subsurface exploration indicated asphalt pavement thicknesses ranging from 1 to 4 inches at most of the test boring locations. Boring B-11, drilled in an unpaved area, encountered only about 1 inch of topsoil.

We encountered between about 4 ft and 7 ft of existing fill in the test borings. The existing fill we encountered in the borings was composed primarily of firm to very stiff silt and clay soils containing varying amounts of crushed stone. A limited amount of wood and other debris was observed within the fill stratum in one of the borings. In general, the existing fill materials we observed in the test borings appeared to be of good quality and may be suitable for support of lightly loaded site walls, floor slabs, and pavements. However, our experience with undocumented existing fill deposits is that they are usually unpredictable with regard to their composition and consistency. Therefore, we do not recommend supporting building foundations on existing fill materials. To adequately evaluate the suitability of the existing fill for support of site retaining walls, floor slabs, and pavements, we recommend that the crushed stone base in pavement areas be removed to expose the surface of the existing fill stratum. Following removal of asphalt pavements and crushed stone base, personnel from our office should visually evaluate the surface of the fill and observe proofrolling by the Contractor with a loaded tandem-axle dump truck. Where deleterious or unsuitably soft existing fill materials are encountered and in areas where building foundations will be constructed, Stratum A existing fill should be removed down to suitable residual soils and be replaced with compacted structural fill.

We anticipate that subgrades consisting of Stratum B residual soils should generally be suitable for support of new compacted structural fill. If soft residual soils are encountered beneath the Stratum A fill, it may be possible to compact them in place if earthwork is performed during warm, dry weather. However, the Contractor may need to scarify and dry these soils to achieve adequate compaction.

As previously discussed, a representative from our office should evaluate the suitability of all compacted structural fill subgrades at the time of construction. The stripped subgrades should be proofrolled with a loaded tandem axle dump truck to evaluate the subgrade suitability for support of the compacted structural fill prior to any undercutting or initiation of fill placement. Areas that exhibit excessive pumping, weaving, or rutting should be scarified, dried and recompacted, or undercut and replaced with compacted structural fill as recommended by our personnel. Subgrade evaluation techniques complementary to proofrolling could include a combination of probing with a penetrometer, drilling hand augers, or observing test pits.

When removal of materials is required, the excavation should be performed in a manner to limit disturbance of the underlying suitable material. The excavation should be performed under the observation of the Geotechnical Engineer to evaluate required excavation depths.

Undercut volumes should be evaluated by cross sectioning. Other methods of calculating volumes of undercut, such as counting trucks, are less accurate and generally result in additional expense. If truck counts are used, we recommend the method of payment be in accordance with Section 109 of *VDOT Road and Bridge Specifications*.

Compacted structural fill subgrades should be kept free of ponded water. If a spring or other flowing water is present at the compacted structural fill subgrade level, the Contractor should direct water to discharge beyond the fill limits. Recommendations for discharging springs should be provided by the Geotechnical Engineer at the time of construction, as appropriate.

Compacted structural fill subgrades should be free of snow, ice, and frozen soils. If snow, ice, or frozen soils are present at subgrade levels, these materials should be removed as recommended by the Geotechnical Engineer.

Some existing structures and underground utilities are present on site. If structures, foundations, and or utilities are encountered during excavation, they will need to be removed or rerouted before compacted structural fill placement. Existing foundations and existing active or abandoned utilities should be completely removed from the proposed building area. Existing foundations and walls in the proposed pavement areas should be removed to at least 3 ft below the design pavement subgrade level. Existing utilities and drainage structures within the building area should be removed and replaced with compacted structural fill.

Compacted structural fill subgrades should not be steeper than about 4H:1V. If steeper slopes are present, subgrades should be benched to permit placement of horizontal lifts of fill.

Compacted Structural Fill

We anticipate that the non-organic on-site soils should generally be suitable for re-use as compacted structural fill. If off-site borrow materials are needed, these soils should classify CL, ML, SC, SM, SP, SW, GC, GM, GP or GW according to ASTM D2487. Fill materials should not contain particles larger than 3 inches. The successful re-use of the excavated, on-site soils as compacted structural fill will depend on their natural moisture contents during excavation. Laboratory test results indicate soils encountered in the test borings are generally wet of the optimum moisture content for compaction. Therefore, scarifying and drying of these soils will likely be required to achieve the recommended compaction and should be anticipated. Drying of these soils will likely result in some delays, and may not be possible during cooler, wetter weather. We recommend that the earthwork be performed during the warmer, drier times of the year.

Compacted structural fill should be placed in maximum 8-inch thick horizontal, loose lifts and should be compacted to at least 95 percent of the maximum dry density per ASTM D698 (Standard Proctor). Soil moisture contents at the time of compaction should be within three percentage points of the soils' optimum moisture content. Backfill placed in excavations, trenches, and other areas that large compaction equipment cannot access should be placed in maximum 6-inch thick lifts. Backfill should meet the material, placement, and compaction requirements outlined above.

Rock Excavation

We encountered refusal on rock in Boring B-01 at a depth of 5.5 ft beneath the ground surface and highly variable depths to rock are common in karst geology. Although we do not anticipate that widespread rock will be encountered during excavation at this site, it is possible that rock excavation techniques may be required to achieve design grades in some deeper cuts and deeper utility excavations. In general, we expect the transition from soil to rock to be abrupt. We also expect that the rock is sufficiently hard that it

cannot be removed with conventional excavation equipment, and that special means of excavation may be needed. Removal of rock may require the use of blasting, air-powered tools, rock splitters, or large hoe rams.

A sample definition of rock for excavation specifications is provided below:

For mass excavation, rock is defined as any material that cannot be dislodged by a Caterpillar Model No. D-8 heavy-duty tractor, or equivalent, equipped with a hydraulically operated, single-tooth power ripper without the use of hoe-ramming or blasting. For trench, footing and pit excavations, rock excavation shall be defined in terms of a Caterpillar Model No. 330 hydraulic excavator, or equivalent. This classification does not include material such as loose rock, concrete, cemented gravel, or other materials that can be removed by means other than hoe-ramming or blasting, but which for reasons of economy in excavating, the Contractor chooses to remove by hoe-ramming or blasting. Rock does not include boulders less than one cubic yard in volume. Boulders larger than one cubic yard in volume will be considered rock for payment purposes.

Spread Footings

Based on the information provided to us, maximum column loads of 50 kips and maximum wall loads of 3 kips per linear foot are anticipated and were used in our foundation analyses. We consider spread footings suitable for support of the proposed structure. Footings should be founded on suitable natural residual soils of Stratum B or on properly placed and compacted structural fill. Compacted structural fill should meet the requirements outlined in the Site Grading and Earthwork section of this report. Existing fill soils of Stratum A are not considered suitable for foundation support. We recommend footings supported on natural residual materials be designed for a net allowable soil bearing pressure of 2,000 psf. This bearing pressure provides a factor of safety against general bearing capacity failure of at least 3.0.

Site retaining wall footings may also be designed for an allowable soil bearing pressure of 2,000 psf. We anticipate that site retaining wall footings may bear on existing fill of Stratum A, provided they are suitable based on our evaluation of the actual subgrades at the time of construction.

The above allowable soil bearing pressure may be increased by 33 percent for wind and seismic loads when used in conjunction with load combinations defined in IBC 2012 Section 1605.3.2, Alternative Basic Load Combinations for use with allowable stress design. This increase is not applicable for other allowable stress load combinations, strength design, or load and resistance factor design.

If existing fill soils of Stratum A or unsuitable soils of Stratum B are encountered at the design bearing grade for building foundations, then they should be undercut and backfilled with compacted structural fill or Controlled Low Strength Material (CLSM, aka flowable fill). Open-graded crushed stone such as VDOT No. 57 aggregate should not be used as undercut backfill as this can create a reservoir for water, saturating the subgrade, and increasing the possibility of swell below the footing, as well as increasing the potential for sinkhole development. All footing subgrades should be observed by a representative from this office prior to placement of concrete to evaluate if subgrade materials are as anticipated.

Settlements of shallow foundations supported on suitable natural soils and on properly placed compacted structural fill are not expected to exceed about 1 inch. Differential settlements between similarly loaded footings are not expected to exceed about half this value.

Column and wall footings should be at least 24 and 16 inches wide, respectively, for shear considerations. Exterior footings should be founded at least 2.5 ft below final exterior grades for frost protection. Interior footings may be founded at nominal depths below the floor slabs. Where bearing grades between adjacent footings vary, the slope between the bottom edges of adjacent footings should not be steeper than 45 degrees (1H:1V).

To limit the potential for damage from moisture-related volume change of foundation soils, site grades should be set to permit positive drainage of surface water away from the building. Roof drainage from the building should be collected and discharged at least 25 ft from the building. Trees should not be planted within 25 ft of the building.

Floor Slabs

The proposed floor slabs should be supported on suitable existing fill of Stratum A, suitable residual soils of Stratum B, or on properly placed and compacted structural fill. A modulus of subgrade reaction, k , of 100 pci should be used in the design of floor slabs. The recommended modulus value is for a 1-ft-square plate. Some slab design software may consider different definitions of k for input. The Structural Engineer should contact our office if their software considers a different definition of k .

A minimum 4-inch thick crushed stone or washed gravel capillary moisture barrier should underlie floor slabs-on-grade. Moisture barrier material should consist of VDOT No. 57 crushed stone. The Contractor should compact the stone in place with at least two passes of suitable vibratory compaction equipment.

The Contractor should compact floor slab subgrades to repair any disturbance that may occur due to construction operations before placing capillary moisture barrier materials. Since floors will be slab-on-grade, footing and utility excavations should be backfilled with compacted structural fill as defined in the Site Grading and Earthwork section of this report.

Walls Below Grade and Cantilever Retaining Walls

Below-grade building walls will be braced by the structure, preventing movement, whereas cantilever retaining walls will be unbraced, allowing movement. Braced basement walls and cantilever retaining walls should be designed considering equivalent fluid pressures as shown on Figures 3 and 4. All walls should be backfilled with VDOT No. 57 stone. We do not recommend using on-site soils as wall backfill because they are highly plastic, poorly draining materials that tend to creep and exert higher lateral pressures on walls. Where applicable, the design should consider surcharge loads using a rectangular earth pressure distribution as shown on Figures 3 and 4. The surcharge pressure ordinate should be obtained by multiplying the surface surcharge pressure, q , by the corresponding factor in Table 5. Horizontal forces on cantilever retaining walls should be resisted by friction acting on the base of the wall and passive earth pressure acting on the front of the wall foundation, as shown on Figure 4. Recommended friction and passive earth pressure factors are presented in Table 5.

Table 5: Recommended Design Parameters for Walls

Wall Type	Backfill Materials	Equivalent Fluid Pressure Factor γ_{EF} (psf)	Surcharge Pressure Factor	Friction Factor	Passive Equivalent Fluid Pressure Factor γ_P (psf)
Braced	No. 57 Stone	42H	0.38q	NA	NA
Cantilevered	No. 57 Stone	35H	0.33q	0.30	350H2

The above parameters consider a horizontal ground surface behind and in front of the walls. We should be contacted to provide alternative parameters if sloping ground surface conditions are anticipated.

The earth pressure recommendations provided do not consider hydrostatic pressure since subdrainage will be provided behind the walls below grade and cantilever retaining walls. For walls below grade, subdrainage should consist of perimeter subdrains located on top of the wall footing, next to the wall. Subdrains should consist of 4-inch perforated Schedule 40 PVC pipe. Subdrains should drain by gravity to an outlet, or to a sump or storm sewer. For cantilever retaining walls, subdrainage may consist of perimeter subdrains as described above or weepholes. Weepholes should be 3 inches in diameter and installed on 8 ft centers.

As discussed, backfill for walls below grade and cantilever retaining walls should consist of VDOT No. 57 stone, placed in the zone extending from the base of the wall footing upwards at 45 degrees. The top 2 ft of wall backfill should consist of on-site soils classifying CH, MH, CL, or ML according to ASTM D2487 to inhibit the infiltration of surface water. Backfill behind interior walls below grade does not need to be capped with 2 ft of low permeability soil backfill. A non-woven geotextile separation fabric consisting of Mirafi 140N, or approved equivalent, should be placed between the open-graded stone and the adjacent earthen bank as well as between the open-graded stone and the 2 ft compacted clay cap.

The Contractor should place the 2 ft clay cap backfill in maximum 8-inch thick loose lifts, and compact each lift to at least 95 percent of maximum dry density according to ASTM D698, Standard Proctor. The Contractor should place No. 57 stone backfill in maximum 12-inch thick lifts, and compact each lift using suitable vibratory equipment. Only light hand-operated equipment should be used to compact backfill against walls. The Structural Engineer of Record should approve the size of the compaction equipment.

Pavements

Asphalt paved driveways and parking spaces will surround the proposed building. For our analyses, we estimated 500 vehicles per day in travel areas and 100 vehicles per day in parking spaces. These volumes include up to five percent truck traffic.

The Contractor should prepare pavement subgrades and place compacted structural fill for pavement support as described in the Site Grading and Earthwork section of this report. Final pavement subgrades

should be proofrolled with a tandem axle dump truck under the observation of the Geotechnical Engineer immediately prior to placing base coarse aggregate to evaluate their suitability to support the pavement.

Dense-graded aggregate placed as pavement base course beneath asphalt should be compacted to at least 95 percent of maximum dry density according to ASTM D698, Standard Proctor. Dense-graded aggregate should be placed in maximum 8-inch thick loose lifts.

We developed the recommended pavement sections according to the Vaswani Design Method for flexible pavements based on a design CBR value of 3.7. This design CBR value represents two-thirds of the average laboratory value for the samples tested from Borings B-06 and B-09. We recommend the following entrance pavement sections:

Table 6: Recommended Asphalt Pavement Sections

Type Section	Thickness (inches)
Heavy Duty – Entrance and Travel Ways	
Asphalt Concrete Surface Course, VDOT SM-9.5A	1.0
Asphalt Concrete Base Course, VDOT BM-25.0A	3.0
Dense-Graded Aggregate Subbase Course, VDOT 21B	6.0
Light Duty – Automobile Parking Spaces	
Asphalt Concrete Surface Course, VDOT SM-9.5A	2.0
Dense-Graded Aggregate Subbase Course, VDOT 21B	6.0

Dumpster approach pads should consist of concrete pavement designed using a modulus of subgrade reaction, k , of 100 pci.

Adequate control of surface drainage will be a very important consideration for the overall performance of this pavement design. The area surrounding pavements should be graded to direct surface water away from paved areas. Utility excavations within pavement areas should be backfilled with compacted structural fill.

CONSTRUCTION CONSIDERATIONS

Karst Considerations

As previously discussed, the project site lies within karst geology underlain by carbonate rocks. In some areas, the limestone is susceptible to chemical weathering and the development of voids in the bedrock. Voids were not detected in the test borings and we did not encounter significant amounts of soft soils in any of the borings. We recommend taking preventative measures during construction to reduce the potential for sinkhole development, as summarized below:

1. Positive drainage away from building areas should be maintained during site grading and throughout construction. Upon completion of daily earthwork operations, the ground surface should be sealed by thorough rolling to reduce infiltration of precipitation and to facilitate runoff.
2. During construction, care should be taken to prevent surface water from ponding in and/or adjacent to the construction areas. Foundations should be excavated and poured the same day, if possible. If concrete placement will not occur the same day as excavation, then subgrades should be nominally undercut and backfilled with a mud mat to limit water infiltration.
3. Karst features that are uncovered or that develop during construction should be brought to the Geotechnical Engineer's attention for remedial improvement.
4. Roof drains should be tied directly into storm drains to channel rain water away from the building.
5. Water-tight storm drains should be used.

Site Grading and Earthwork

The on-site soils are susceptible to moisture changes, will be easily disturbed, and will be difficult to compact under wet weather conditions. Drying and reworking of the soils are likely to be difficult during periods of wet weather. We recommend that the earthwork phases of this project be performed during the warmer, drier times of the year to limit the potential for disturbance of on-site soils.

The soils at this site consist primarily of moderately to highly plastic clays and silts. These soils are moisture sensitive and will become readily disturbed by construction traffic on exposed wet surfaces. We recommend avoiding wet weather site preparation and grading activities. If wet weather work is performed, the quantities of disturbed soils to be excavated can be expected to increase.

The Contractor should limit traffic on stripped or undercut subgrades to reduce disturbance of underlying soils. The Contractor should provide site drainage to maintain subgrades free of water and to avoid saturation and disturbance of the subgrade soils before placing compacted structural fill, pavement base course, or moisture barrier material. This site drainage will be important during all phases of the construction work. The Contractor should be responsible for reworking of subgrades and compacted structural fill that were initially considered suitable but were later disturbed by equipment and/or weather.

Spread Footings

The Contractor should exercise care during excavation for spread footings so that as little disturbance as possible occurs at the foundation level. The Contractor should carefully clean loose or soft soils from the bottom of excavations before placing concrete. A Geotechnical Engineer from our firm should observe footing subgrades prior to concrete placement to evaluate whether subgrade soils are as anticipated in this report.

The potential for variation of moisture content in foundation soils is probably greatest during construction. If the moisture content of foundation soils increases or decreases during construction, a moisture-related change in volume will likely occur as these soils return to their natural moisture content. Therefore, prompt placement of concrete, backfilling, and grading are very important for proper foundation performance. The Contractor should place footing concrete immediately after excavation of the footing to prevent accumulation of water in the excavation or drying of foundation soils. If foundation concrete cannot be placed immediately, then mud-mats consisting of lean concrete should be placed over the

subgrades immediately after excavation and evaluation of spread footing subgrades to protect bearing materials from deteriorating.

Forms may be used if necessary, but less subgrade disturbance is expected if excavations are made to the required dimensions, and concrete is placed against the soil. If footings are formed, the forms should be pulled and the excavation backfilled as soon as possible. Water should not be allowed to pond along the outside of footings for long periods of time.

We encountered groundwater in Boring B-10 at a depth of about 6 ft, approximate El 2092. We believe this was perched water and we generally do not anticipate that groundwater will be encountered in most excavations at this site. If groundwater is encountered, we anticipate that pumping from sump pits within the excavations can control groundwater.

Engineering Services During Construction

The engineering recommendations provided in this report are based on the information obtained from the subsurface exploration and laboratory testing. However, conditions on the site may vary between the discrete locations observed at the time of our subsurface exploration. The nature and extent of variations between borings may not become evident until during construction.

To account for this variability, we should provide professional observation and testing of subsurface conditions revealed during construction as an extension of our engineering services. These services will also help in evaluating the Contractor's conformance with the plans and specifications in accordance with building code requirements. Because of our unique position to understand the intent of the geotechnical engineering recommendations, retaining Schnabel for these services will allow the owner to receive consistent service throughout the project construction.

General Specification Recommendations

An allowance should be established to account for possible additional costs that may be required to construct earthwork and foundations as recommended in this report. Additional costs may be incurred for a variety of reasons including variation of soil between borings, unanticipated debris, greater than anticipated unsuitable soils, need for borrow fill material, wet on-site soils, existing foundations, obstructions, sinkhole mitigation, etc.

The project specifications should indicate the Contractor's responsibility for providing adequate site drainage during construction. Inadequate drainage will most likely lead to disturbance of soils by construction traffic and increased volume of undercut.

This report may be made available to prospective bidders for informational purposes. We recommend that the project specifications contain the following statement:

Schnabel Engineering, LLC, has prepared this geotechnical engineering report for this project. This report is for informational purposes only and is not part of the contract documents. The opinions expressed represent the Geotechnical Engineer's interpretation of the subsurface conditions, tests, and the results of analyses performed. Should the data contained in this report

not be adequate for the Contractor's purposes, the Contractor may make, before bidding, independent exploration, tests and analyses. This report may be examined by bidders at the office of the Owner, or copies may be obtained from the Owner at nominal charge.

Additional data and reports prepared by others that could have an impact upon the Contractor's bid should also be made available to prospective bidders for informational purposes.

LIMITATIONS

We based the analyses and recommendations submitted in this report on the information revealed by our exploration. We attempted to provide for normal contingencies, but the possibility remains that unexpected conditions may be encountered during construction.

This report has been prepared to aid in the evaluation of this site and to assist in the design of the project. It is intended for use concerning this specific project. We based our recommendations on information on the site and proposed construction as described in this report. Substantial changes in loads, locations, or grades should be brought to our attention so we can modify our recommendations as needed.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or other instrument of service.

Montgomery County, Virginia
Montgomery County Magistrate and Court Services Building

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this report.

Sincerely,

SCHNABEL ENGINEERING, LLC



Saujan Niraula
Senior Staff Engineer



Steven J. Winter, PE
Principal

Figures

Appendix A: Subsurface Exploration Data
Appendix B: Soil Laboratory Test Data

Distribution:

Montgomery County (Electronic)
Attn: Scott Woodrum, PE

Thompson & Litton, Inc. (Electronic)
Attn: Barry Collier, AIA

FIGURES

- Figure 1: Site Vicinity Map
- Figure 2: Test Boring Location Plan
- Figure 3: Earth Pressure Recommendations – Building Walls Below Grade
- Figure 4: Earth Pressure Recommendations – Cantilever Retaining Walls



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
 Esri, HERE, Garmin, (c) OpenStreetMap contributors
 Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
 Projection: WGS 1984 Web Mercator Auxiliary Sphere

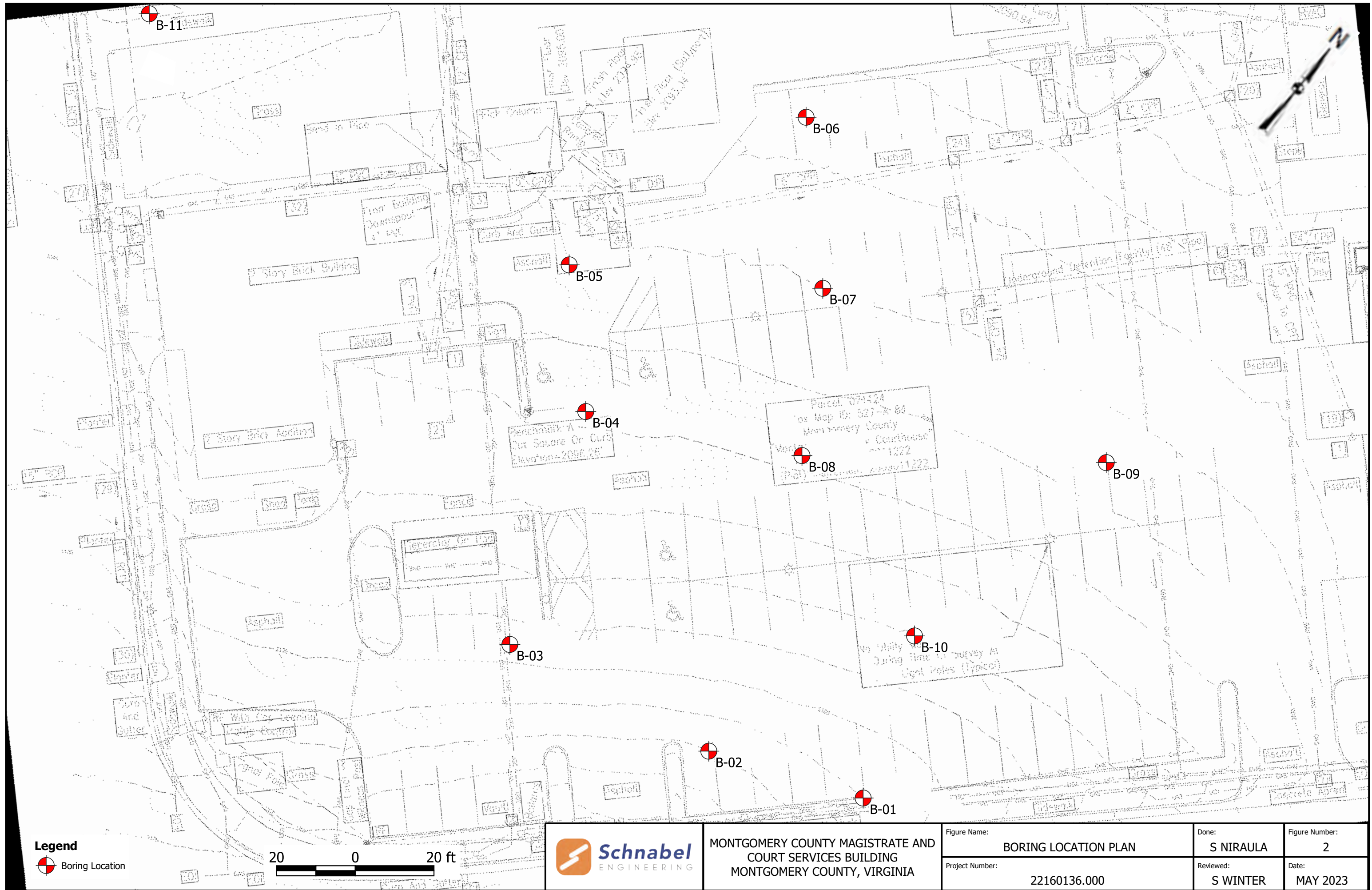
NOT TO SCALE



MONTGOMERY COUNTY MAGISTRATE
 AND COURT SERVICES BUILDING
 CHRISTIANSBURG, VIRGINIA
 PROJECT NO. 22160136.000

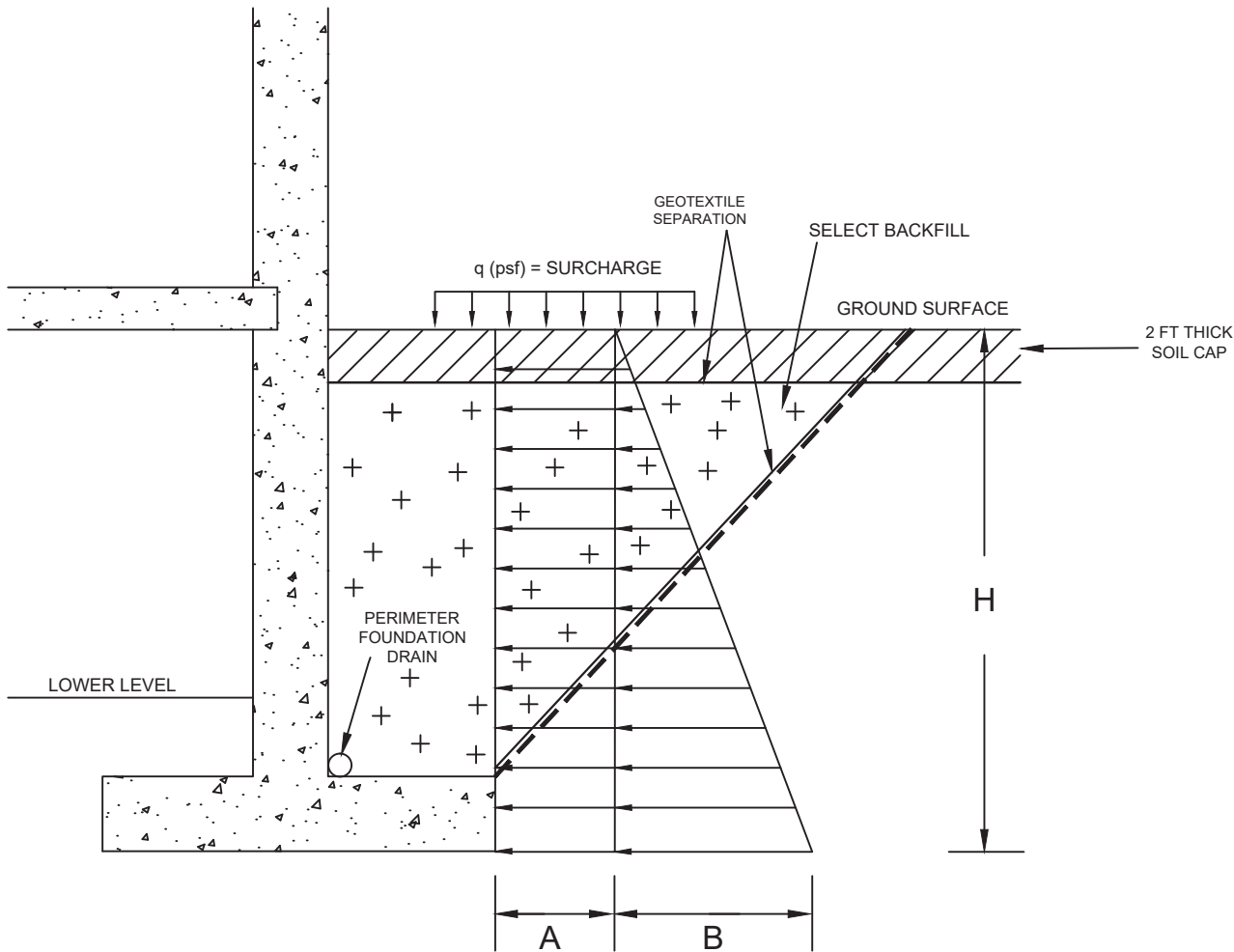
SITE VICINITY
 MAP

FIGURE 1



EARTH PRESSURE RECOMMENDATIONS
BUILDING WALLS BELOW GRADE

NO SCALE



BACKFILL
VDOT NO. 57 STONE A B
0.38q 42H (psf)

A - SURCHARGE LOADING
B - EQUIVALENT FLUID PRESSURE



MONTGOMERY COUNTY
MAGISTRATE AND COURT
SERVICES BUILDING
CHRISTIANSBURG, VIRGINIA

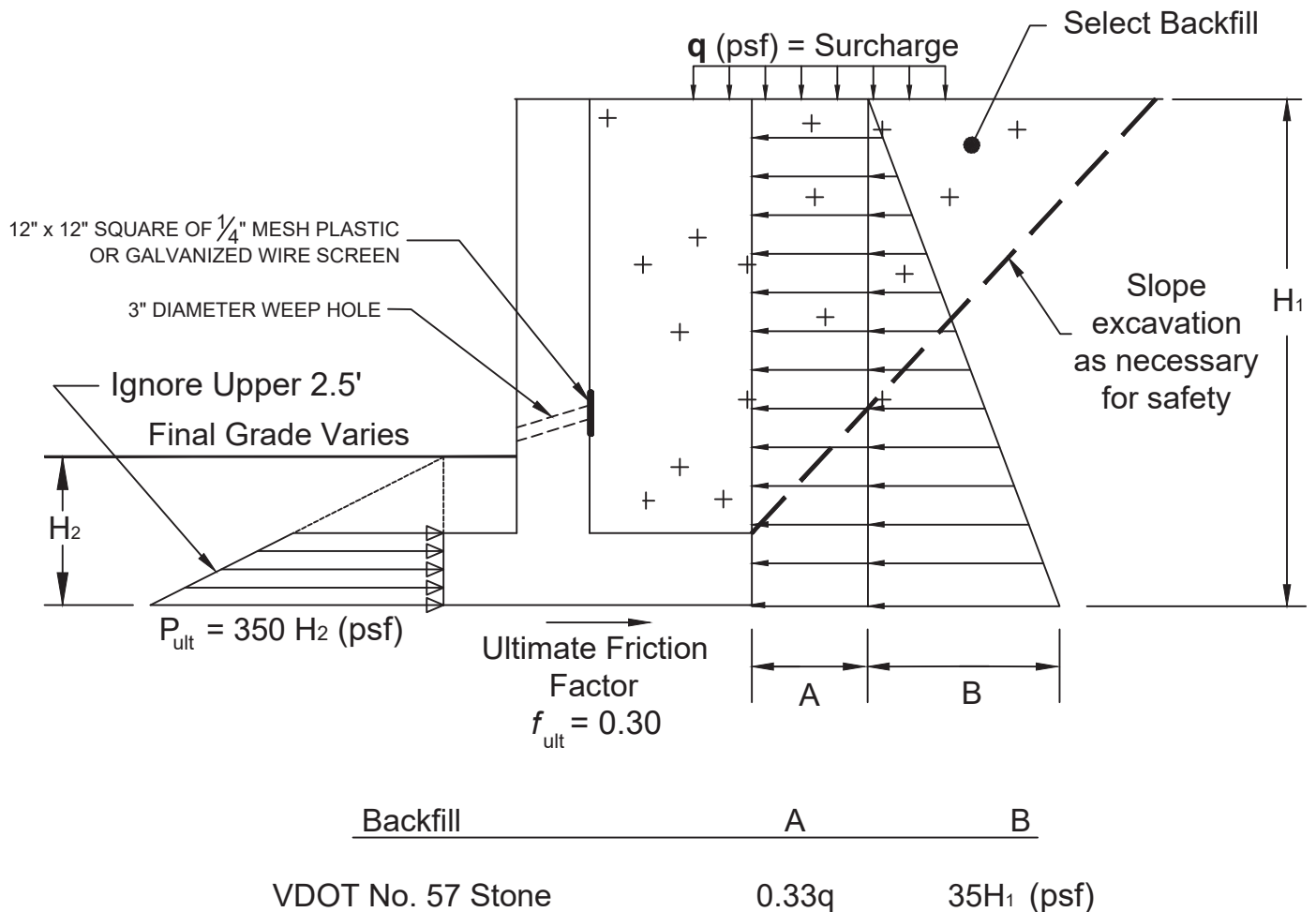
Figure Name:
EARTH PRESSURE RECOMMENDATIONS -
BUILDING WALLS BELOW GRADE
Project Number:
22160136.000

Done:
S. NIRLA
Reviewed:
S. WINTER

Figure Number:
3
Date:
MAY 2023

EARTH PRESSURE RECOMMENDATIONS CANTILEVER RETAINING WALLS (HORIZONTAL BACKFILL)

NO SCALE



A - Surcharge Loading
B - Equivalent Fluid Pressure



MONTGOMERY COUNTY
MAGISTRATE AND COURT
SERVICES BUILDING
CHRISTIANSBURG, VIRGINIA

Figure Name:
EARTH PRESSURE RECOMMENDATIONS -
CANTILEVER WALLS

Project Number:
22160136.000

Done:
S. NIRLAULA

Reviewed:
S. WINTER

Figure Number:
4

Date:
MAY 2023

APPENDIX A

SUBSURFACE EXPLORATION DATA

Subsurface Exploration Procedures
General Notes for Subsurface Exploration Logs
Identification of Soil
Boring Logs, B-1 through B-11

SUBSURFACE EXPLORATION PROCEDURES

Test Borings – Hollow Stem Augers

The borings are advanced by turning a continuous flight auger with a center opening of 2¼ or 3¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger, by standard methods, after removal of the plug. Usually, no water is introduced into the boring using this procedure.

Standard Penetration Test Results

The numbers in the Sampling Data column of the boring logs represent Standard Penetration Test (SPT) results. Each number represents the blows needed to drive a 2-inch O.D., 1½-inch I.D. split-spoon sampler 6 inches, using a 140-pound hammer falling 30 inches. The sampler is typically driven a total of 18 or 24 inches. The first 6 inches are considered a seating interval. The total of the number of blows for the second and third 6-inch intervals is the SPT “N-value.” The SPT is performed according to ASTM D1586.

Soil Classification Criteria

The group symbols on the logs represent the Unified Soil Classification System Group Symbols (ASTM D2487) based on visual observation and limited laboratory testing of the samples. Criteria for visual identification of soil samples are included in this appendix. Some variation can be expected between samples visually classified and samples classified in the laboratory.

Residual soils are derived through the in-place physical and chemical weathering of the underlying rock. Disintegrated rock is defined as residual material with SPT N-values between 60 blows per foot and refusal. Refusal is defined as an N-value of 50 blows for a penetration of one inch or less.

Pocket Penetrometer Results

The values following “PP=” in the sampling data column of the logs represent pocket penetrometer readings. Pocket penetrometer readings provide an estimate of the unconfined compressive strength of fine-grained soils.

Boring Locations and Elevations

Boring locations were staked by our personnel using sub-meter GPS equipment. Approximate boring locations are shown on Figure 2. Ground surface elevations at the boring locations were obtained from the site topographic plan and are indicated on the boring logs. Locations and elevations should be considered no more accurate than the methods used to determine them.

GENERAL NOTES FOR SUBSURFACE EXPLORATION LOGS

1. Numbers in sampling data column next to Standard Penetration Test (SPT) symbols indicate blows required to drive a 2-inch O.D., 1¾-inch I.D. sampling spoon 6 inches using a 140 pound hammer falling 30 inches. The Standard Penetration Test (SPT) N-value is the number of blows required to drive the sampler 12 inches, after a 6 inch seating interval. The Standard Penetration Test is performed in general accordance with ASTM D1586.
2. Visual classification of soil is in accordance with terminology set forth in "Identification of Soil." The ASTM D2487 group symbols (e.g., CL) shown in the classification column are based on visual observations.
3. Estimated water levels indicated on the logs are only estimates from available data and may vary with precipitation, porosity of the soil, site topography, and other factors.
4. Refusal at the surface of rock, boulder, or other obstruction is defined as an SPT resistance of 50 blows for 1 inch or less of penetration.
5. The logs and related information depict subsurface conditions only at the specific locations and at the particular time when drilled or excavated. Soil conditions at other locations may differ from conditions occurring at these locations. Also, the passage of time may result in a change in the subsurface soil and water level conditions at the subsurface exploration location.
6. The stratification lines represent the approximate boundary between soil and rock types as obtained from the subsurface exploration. Some variation may also be expected vertically between samples taken. The soil profile, water level observations and penetration resistances presented on these logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.
7. Key to symbols and abbreviations:



S-1, SPT
5+10+1

Sample No., Standard Penetration Test
Number of blows in each 6-inch increment



UD-1, UNDIST
Rec=24", 100%

Sample No., 2" or 3" Undisturbed Tube Sample
Recovery in inches, Percent Recovery



Run #1, CORE
Run = 5.0 ft
REC = 60", 100%
RQD = 60", 100%

Core No., Rock Core
Run length in feet
Recovery in inches, Percent Recovery
RQD in inches, Percent RQD

GP

Geostick Penetration Reading (inches)

LL

Liquid Limit

MC

Moisture Content (percent)

PL

Plastic Limit

PP

Pocket Penetrometer Reading (tsf)

%Passing#200

Percent by weight passing a No. 200 Sieve

IDENTIFICATION OF SOIL

I. DEFINITION OF SOIL GROUP NAMES (ASTM D2487)

SYMBOL GROUP NAME

Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels – More than 50% of coarse fraction retained on No. 4 sieve Coarse, ¾" to 3" Fine, No. 4 to ¾"	Clean Gravels Less than 5% fines	GW	WELL GRADED GRAVEL
			GP	POORLY GRADED GRAVEL
		Gravels with fines More than 12% fines	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	Sands – 50% or more of coarse Fraction passes No. 4 sieve Coarse, No. 10 to No. 4 Medium, No. 40 to No. 10 Fine, No. 200 to No. 40	Clean Sands Less than 5% fines	SW	WELL GRADED SAND
			SP	POORLY GRADED SAND
		Sands with fines More than 12% fines	SM	SILTY SAND
			SC	CLAYEY SAND
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays – Liquid Limit less than 50 Low to medium plasticity	Inorganic	CL	LEAN CLAY
			ML	SILT
		Organic	OL	ORGANIC CLAY ORGANIC SILT
			Silts and Clays – Liquid Limit 50 or more Medium to high plasticity	Inorganic
	MH	ELASTIC SILT		
	Organic	OH		ORGANIC CLAY ORGANIC SILT
		Highly Organic Soils		Primarily organic matter, dark in color and organic odor

II. DEFINITION OF SOIL COMPONENT PROPORTIONS (ASTM D2487)

Examples




Adjective Form	GRAVELLY SANDY	>30% to <50% coarse grained component in a fine-grained soil	GRAVELLY LEAN CLAY
	CLAYEY SILTY	>12% to <50% fine grained component in a coarse-grained soil	SILTY SAND
"With"	WITH GRAVEL WITH SAND	>15% to <30% coarse grained component in a fine-grained soil	FAT CLAY WITH GRAVEL
	WITH GRAVEL WITH SAND	>15% to <50% coarse grained component in a coarse-grained soil	POORLY GRADED GRAVEL WITH SAND
	WITH SILT WITH CLAY	>5% to <12% fine grained component in a coarse-grained soil	POORLY GRADED SAND WITH SILT

III. GLOSSARY OF MISCELLANEOUS TERMS

SYMBOLS	Unified Soil Classification Symbols are shown above as group symbols. A dual symbol "-" indicates the soil belongs to two groups. A borderline symbol "/" indicates the soil belongs to two possible groups.
FILL	Man-made deposit containing soil, rock and often foreign matter.
PROBABLE FILL	Soils which contain no visually detected foreign matter but which are suspect with regard to origin.
DISINTEGRATED ROCK (DR)	Residual materials with a standard penetration resistance (SPT) between 60 blows per foot and refusal. Refusal is defined as an SPT of 100 blows for 2" or less penetration.
BOULDERS & COBBLES	Boulders are considered rounded pieces of rock larger than 12 inches, while cobbles range from 3 to 12-inch size.
LENSES	0 to ½-inch seam within a material in a test pit.
LAYERS	½ to 12-inch seam within a material in a test pit.
POCKET	Discontinuous body within a material in a test pit.
MOISTURE CONDITIONS	Wet, moist or dry to indicate visual appearance of specimen.
COLOR	Overall color, with modifiers such as light to dark or variation in coloration.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-01**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: Paul Smith
Schnabel Representative: Saujan Niraula
Equipment: CME-55 (Track)
Method: 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)
Dates Started: 3/1/23 **Finished:** 3/1/23
X: 10926924.15 ft **Y:** 3576316.87 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2101± (ft) **Total Depth:** 5.5 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/1	---	Dry	5.5'	---
Casing Pulled	3/1	---	Dry	---	2.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRA TUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.3	Asphalt		2100.7	A		S-01, SPT 6+7+13 REC=6", 33%	MC = 26.9% PP = 3.50 tsf	Asphalt pavement
1.5	Crushed stone		2099.5			S-02, SPT 7+8+8 REC=12", 67%		Fill
4.0	FILL, sampled as lean clay with sand; moist, orangish- brown, trace gravel	FILL	2097.0			S-03, SPT 50/4" REC=3", 75%		Residual
5.5	DISINTEGRATED ROCK, sampled as silty sand, fine to coarse; moist, light brown, few gravel	DR	2095.5	C	5			

Bottom of Boring at 5.5 ft.
Auger refusal at 5.5 ft.
Boring terminated at auger refusal.
Boring backfilled with cuttings upon completion.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-01A**
Contract Number: 22160136.000
Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc. Blacksburg, Virginia Contractor Foreman: Paul Smith Schnabel Representative: Saujan Niraula Equipment: CME-55 (Track) Method: 2-1/4" I.D. Hollow Stem Auger Hammer Type: Auto Hammer (140 lb) Dates Started: 3/1/23 Finished: 3/1/23 X: 10926924.15 ft Y: 3576316.87 ft Coordinate System: VA State Plane (S) Plunge: -90 Bearing: Ground Surface Elevation: 2101± (ft) Total Depth: 9.5 ft	Water Level Observations					
		Date	Time	Depth	Casing	Caved
	Completion	3/1	---	Dry	9.5'	---
	Casing Pulled	3/1	---	Dry	---	6.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
	Auger probe to 7.0 ft, see B-01 for stratigraphy			A		AUGER		Fill
7.0	SILTY GRAVEL, fine to coarse; moist, light brown and gray	GM	2094.0	B		S-01, SPT 5+13+24 REC=10", 56%	MC = 8.2%	Residual
9.0	DISINTEGRATED ROCK, sampled as silty gravel with clay, fine to coarse; moist, light brown	DR	2092.0	C		S-02, SPT 50/2" REC=1", 50%		
9.5			2091.5					

Bottom of Boring at 9.5 ft.
Auger refusal at 9.5 ft.
Boring terminated at auger refusal.
Boring backfilled with cuttings upon completion.
Offset 4.5 ft East of B-01

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-02****Contract Number:** 22160136.000**Sheet:** 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/1/23 **Finished:** 3/1/23**X:** 10926886.18 ft **Y:** 3576301.4441 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2102± (ft) **Total Depth:** 19.3 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/1	---	Dry	19.3'	---
Casing Pulled	3/1	---	Dry	---	8.3'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.2	Asphalt		2101.8					Asphalt pavement Fill
0.5	Crushed stone		2101.5					
	FILL, sampled as lean clay with gravel; moist, brown and orangish- brown	FILL		A		S-01, SPT 4+7+8 REC=14", 78%	MC = 15.2% PP = 0.50 tsf	
						S-02, SPT 4+7+3 REC=4", 22%		
				5		S-03, SPT 3+4+5 REC=1", 6%		
6.0	ELASTIC SILT WITH SAND; moist, orangish- brown, trace gravel	MH	2096.0			S-04, SPT 3+2+2 REC=18", 100%	PP = 2.00 tsf MC = 37.5%	Residual
8.5	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel		2093.5			S-05, SPT 7+8+13 REC=18", 100%	PP = 1.50 tsf	
		CH		B	10			
						S-06, SPT 2+2+2 REC=18", 100%	MC = 38.4% PP = 2.50 tsf	
				15				
19.0	DISINTEGRATED ROCK, sampled as silty sand with gravel, fine to coarse; moist, light brown	DR	2083.0	C		S-07, SPT 8+50/4" REC=5", 50%		
19.3			2082.7					

Bottom of Boring at 19.3 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-03**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/2/23 **Finished:** 3/2/23**X:** 10926829.84 ft **Y:** 3576290.7012 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2100± (ft) **Total Depth:** 15.0 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/2	---	Dry	15.0'	---
Casing Pulled	3/2	---	Dry	---	5.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.4	Asphalt		2099.6	A				Asphalt pavement
0.8	Crushed stone		2099.2					Fill
2.0	FILL, sampled as clayey gravel, fine to coarse; moist, light brown	FILL	2098.0			S-01, SPT 5+3+11 REC=14", 78%	PP = 2.50 tsf	
	FILL, sampled as fat clay with sand; moist, orangish- brown and brown, trace gravel	FILL	2096.0			S-02, SPT 3+3+5 REC=16", 89%		
4.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH	2092.5	5		S-03, SPT 1+1+1 REC=16", 89%	MC = 40.9% PP = 2.00 tsf	Residual
7.5	ELASTIC SILT WITH SAND; moist, orangish- brown and brown, trace gravel	MH		B		S-04, SPT 2+3+5 REC=18", 100%	MC = 41.4% PP = 2.00 tsf	
					10	S-05, SPT 7+3+4 REC=18", 100%	PP = 1.50 tsf	
14.0	SANDY ELASTIC SILT; moist, orangish- brown, trace gravel	MH	2086.0			S-06, SPT 2+3+4 REC=18", 100%	MC = 42.2% PP = 1.50 tsf	
15.0			2085.0		15			

Bottom of Boring at 15.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-04**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: Paul Smith
Schnabel Representative: Saujan Niraula
Equipment: CME-55 (Track)
Method: 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)
Dates Started: 3/2/23 **Finished:** 3/2/23
X: 10926807.6 ft **Y:** 3576348.7999 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2096± (ft) **Total Depth:** 12.5 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/2	---	Dry	12.5'	---
Casing Pulled	3/2	---	Dry	---	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRA TUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.4	Asphalt		2095.6			S-01, SPT 10+6+11 REC=14", 78%	PP = 3.00 tsf	Asphalt pavement
1.0	Crushed stone		2095.0			S-02, SPT 6+7+8 REC=14", 78%	PP = 3.00 tsf	Fill
3.5	FILL, sampled as lean clay with gravel; moist, brown, trace sand, contains wood fragments	FILL	2092.5	A	5	S-03, SPT 4+5+5 REC=14", 78%	MC = 22.0% PP = 1.00 tsf	
7.0	FILL, sampled as elastic silt with sand; moist, orangish- brown, trace gravel	FILL	2089.0			S-04, SPT 3+4+4 REC=12", 67%	MC = 33.7% PP = 2.50 tsf	Residual
	FAT CLAY WITH SAND, fine to coarse; moist, orangish- brown, trace gravel	CH		B	10	S-05, SPT 2+3+4 REC=6", 33%	MC = 40.2%	
12.5			2083.5			S-06, SPT 50/0" REC=0"		

Bottom of Boring at 12.5 ft.
Auger refusal at 12.5 ft.
Boring terminated at auger refusal.
Boring backfilled with cuttings upon completion.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-05****Contract Number:** 22160136.000**Sheet:** 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/2/23 **Finished:** 3/2/23**X:** 10926780.88 ft **Y:** 3576375.0974 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2094± (ft) **Total Depth:** 18.7 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/2	---	Dry	18.7'	---
Casing Pulled	3/2	---	Dry	---	3.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.3	Asphalt		2093.7			S-01, SPT 12+10+9 REC=12", 67%		Asphalt pavement
1.5	Crushed stone		2092.5			S-02, SPT 4+2+4 REC=18", 100%	MC = 24.3% PP = 1.00 tsf	Fill
4.0	FILL, sampled as elastic silt with sand; moist, orangish- brown, trace gravel	FILL	2090.0	A		S-03, SPT 2+3+5 REC=16", 89%	MC = 31.0% PP = 2.50 tsf	Residual
	ELASTIC SILT WITH SAND, fine to coarse; moist, orangish- brown, trace gravel	MH		5		S-04, SPT 2+3+5 REC=18", 100%	PP = 2.50 tsf	
7.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel		2087.0			S-05, SPT 4+5+9 REC=18", 100%	PP = 3.00 tsf	
				10		S-06, SPT 3+3+16 REC=18", 100%	MC = 40.1% PP = 3.00 tsf	
	Change: orangish- brown and gray	CH		15				
18.7	DISINTEGRATED ROCK, sampled as sandy silt with gravel; moist, brown	DR	2075.3	C		S-07, SPT 50/2" REC=0", 0%		

Bottom of Boring at 18.7 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

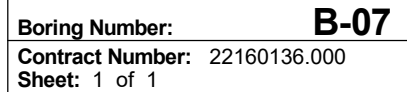
TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07 06.GDT 4/14/23

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-06****Contract Number:** 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/1/23 **Finished:** 3/1/23**X:** 10926804.07 ft **Y:** 3576442.1156 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2093± (ft) **Total Depth:** 19.8 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/1	---	17.3'	19.8'	---
Casing Pulled	3/1	---	Dry	---	5.7'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.1	Asphalt		2092.9			S-01, SPT 7+6+4 REC=18", 100% Bulk 01, GRAB	PP = 3.50 tsf	Asphalt pavement
1.0	Crushed stone		2092.0				LL = 72 PL = 26 % Passing #200 = 82.2	Fill
2.0	FILL, sampled as fat clay with sand; moist, reddish- brown, few gravel	FILL	2091.0			S-02, SPT 2+2+4 REC=18", 100%	PP = 0.50 tsf	
4.0	FILL, sampled as fat clay with sand; moist, orangish- brown, few gravel	FILL	2089.0	A	5	S-03, SPT 2+3+4 REC=12", 67%	MC = 41.8% PP = 0.50 tsf	
7.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH	2086.0		10	S-04, SPT 3+3+3 REC=18", 100%	MC = 43.9% PP = 3.50 tsf	Residual
						S-05, SPT 3+4+5 REC=18", 100%	PP = 2.50 tsf	
14.5	SILTY GRAVEL WITH SAND, fine to coarse; moist, light brown	GM	2078.5	B	15	S-06, SPT 3+5+6 REC=18", 100%	MC = 45.3%	
19.5			2073.5	C		S-07, SPT WOH/12"+50/4 REC=4", 25%		
19.8	DISINTEGRATED ROCK, sampled as sandy silt with gravel; wet, light brown	DR	2073.2					

Bottom of Boring at 19.8 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.



	Water Level Observations				
	Date	Time	Depth	Casing	Caved
Completion	3/1	---	Dry	20.0'	---
Casing Pulled	3/1	---	Dry	---	---

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRA TUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.2	Asphalt		2093.8	A			PP = 3.50 tsf	Asphalt pavement
0.8	Crushed stone		2093.2					
	FILL, sampled as fat clay with sand; moist, reddish- brown, few gravel	FILL						
4.0	ELASTIC SILT WITH SAND; moist, orangish- brown, trace gravel	MH	2090.0	B	5	S-03, SPT 3+2+3 REC=18", 100%	MC = 38.8% PP = 1.00 tsf	Residual
9.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH	2085.0		10	S-05, SPT 2+2+3 REC=18", 100%	PP = 1.50 tsf	
	Change: light brown				15	S-06, SPT 2+3+3 REC=18", 100%	MC = 48.6% PP = 1.50 tsf	
						</		

Bottom of Boring at 20.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-07A**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia
Contractor Foreman: Paul Smith
Schnabel Representative: Saujan Niraula
Equipment: CME-55 (Track)
Method: 3-1/4" I.D. Hollow Stem Auger

Hammer Type: Auto Hammer (140 lb)
Dates Started: 3/1/23 **Finished:** 3/1/23
X: 10926834.7 ft **Y:** 3576411.031 ft
Coordinate System: VA State Plane (S)
Plunge: -90 **Bearing:**
Ground Surface Elevation: 2094± (ft) **Total Depth:** 12.0 ft

Water Level Observations					
Date	Time	Depth	Casing	Caved	

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL		ELEV (ft)	STRA TUM	SAMPLING		TESTS	REMARKS
						DEPTH	DATA		
	Auger probe to 10.0 feet for UD sample, see B-07 for stratigraphy						AUGER		
						5			
10.0				2084.0		10	ST-1, UNDIST REC=18", 75%		
							UD		

Bottom of Boring at 12.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.
Offset 2 feet East of B-07 for UD sample

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-08**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/1/23 **Finished:** 3/1/23**X:** 10926857.33 ft **Y:** 3576374.68 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2096± (ft) **Total Depth:** 15.0 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/1	---	Dry	15.0'	---
Casing Pulled	3/1	---	Dry	---	3.5'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.3	Asphalt		2095.7					Asphalt pavement
0.7	Crushed stone		2095.3					
2.0	FILL, sampled as lean clay with sand; moist, brown, few gravel	FILL	2094.0	A		S-01, SPT 5+7+8 REC=14", 78%	PP = 4.00 tsf	Fill
	FILL, sampled as fat clay with sand; moist, orangish- brown, trace gravel	FILL				S-02, SPT 4+5+6 REC=16", 89%	MC = 32.9% PP = 2.50 tsf	
4.0	FAT CLAY WITH SAND; moist, reddish- brown with mottles of black, trace gravel	CH	2092.0	5		S-03, SPT 5+8+8 REC=18", 100%	PP = 3.00 tsf	Residual
	Change: orangish- brown and light gray					S-04, SPT 3+3+4 REC=18", 100%	MC = 32.7% PP = 2.50 tsf	
9.0	FAT CLAY WITH SAND; moist, orangish- brown, few gravel	CH	2087.0	10		S-05, SPT 3+7+4 REC=18", 100%	PP = 1.00 tsf	
13.0	DISINTEGRATED ROCK, sampled as silty gravel, fine to coarse; moist, gray	DR	2083.0	C				
15.0			2081.0		15	S-06, SPT 50 REC=4", 67%		

Bottom of Boring at 15.0 ft.

Auger refusal at 15.0 ft.

Boring terminated at auger refusal.

Boring backfilled with cuttings upon completion.

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07 06.GDT 4/14/23

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-09**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/1/23 **Finished:** 3/1/23**X:** 10926918.54 ft **Y:** 3576421.9502 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2094± (ft) **Total Depth:** 15.0 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Completion	3/1	---	Dry	15.0'	---
Casing Pulled	3/1	---	Dry	---	1.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRA TUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.1	Asphalt		2093.9					Asphalt pavement
0.5	Crushed stone		2093.5					
	FILL, sampled as fat clay with sand; moist, orangish- brown, trace gravel	FILL		A		S-01, SPT 4+3+4 REC=14", 78% Bulk 01, GRAB S-02, SPT 4+4+5 REC=7", 39%	PP = 4.00 tsf LL = 76 PL = 30 % Passing #200 = 93.2 PP = 2.00 tsf	Fill
4.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH	2090.0		5	S-03, SPT 3+4+3 REC=18", 100%	MC = 42.9% PP = 3.50 tsf	Residual
7.0	ELASTIC SILT WITH SAND; moist, orangish- brown, trace gravel	MH	2087.0			S-04, SPT 3+3+2 REC=18", 100%	MC = 42.7% PP = 1.00 tsf	
9.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel		2085.0	B	10	S-05, SPT 2+3+3 REC=18", 100%	PP = 1.50 tsf	
		CH				S-06, SPT 2+4+5 REC=18", 100%	MC = 38.5% PP = 2.00 tsf	
15.0			2079.0		15			

Bottom of Boring at 15.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-10**
Contract Number: 22160136.000
Sheet: 1 of 1**Contractor:** Blue Ridge Drilling, Inc.
Blacksburg, Virginia**Contractor Foreman:** Paul Smith**Schnabel Representative:** Saujan Niraula**Equipment:** CME-55 (Track)**Method:** 2-1/4" I.D. Hollow Stem Auger**Hammer Type:** Auto Hammer (140 lb)**Dates Started:** 3/1/23 **Finished:** 3/1/23**X:** 10926908.38 ft **Y:** 3576357.0779 ft**Coordinate System:** VA State Plane (S)**Plunge:** -90**Bearing:****Ground Surface Elevation:** 2098± (ft) **Total Depth:** 20.0 ft**Water Level Observations**

	Date	Time	Depth	Casing	Caved
Encountered	3/1	---	6.0'	---	---
Completion	3/1	---	Dry	20.0'	---
Casing Pulled	3/1	---	5.7'	---	5.9'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRA TUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.3	Asphalt		2097.7			S-01, SPT 7+8+6 REC=10", 56%		Asphalt pavement
1.5	Crushed stone		2096.5			S-02, SPT 2+3+4 REC=18", 100%	PP = 2.50 tsf	Fill
4.0	FILL, sampled as fat clay with sand; moist, orangish- brown, trace gravel	FILL	2094.0	A		S-03, SPT 2+3+5 REC=18", 100%	MC = 37.0% PP = 3.50 tsf	Residual
	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH		5		S-04, SPT 2+3+4 REC=18", 100%	MC = 42.6% PP = 2.50 tsf	
9.0	ELASTIC SILT WITH SAND; moist, orangish- brown and brown, trace gravel	MH	2089.0		10	S-05, SPT 2+2+3 REC=18", 100%	PP = 1.50 tsf	
12.0	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH	2086.0	B	15	S-06, SPT 2+3+4 REC=18", 100%	PP = 1.00 tsf	
						S-07, SPT 2+4+5 REC=18", 100%	MC = 48.0% PP = 0.50 tsf	
20.0			2078.0		20			

Bottom of Boring at 20.0 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

TEST BORING LOG BORING LOGS.GPJ SCHNABEL DATA TEMPLATE 2008_07 06.GDT 4/14/23

**TEST
BORING
LOG****Project:** Montgomery County Magistrate and
Court Services Building
Christiansburg, Virginia**Boring Number:** **B-11**
Contract Number: 22160136.000
Sheet: 1 of 1

Contractor: Blue Ridge Drilling, Inc.
Blacksburg, Virginia

Contractor Foreman: Paul Smith

Schnabel Representative: Saujan Niraula

Equipment: CME-55 (Track)

Method: 2-1/4" I.D. Hollow Stem Auger

Hammer Type: Auto Hammer (140 lb)

Dates Started: 3/1/23 **Finished:** 3/1/23

X: 10926667.76 ft **Y:** 3576348.2951 ft

Coordinate System: VA State Plane (S)

Plunge: -90 **Bearing:**

Ground Surface Elevation: 2092± (ft) **Total Depth:** 5.5 ft

Water Level Observations

	Date	Time	Depth	Casing	Caved
Completion	3/1	---	Dry	5.5'	---
Casing Pulled	3/1	---	Dry	---	2.0'

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOL	ELEV (ft)	STRATUM	SAMPLING		TESTS	REMARKS
					DEPTH	DATA		
0.1	Topsoil		2091.9			S-01, SPT 2+3+6 REC=16", 89%		Fill
2.0	FILL, sampled as poorly graded gravel with silt and sand, fine to coarse; moist, light brown and gray	FILL	2090.0	A		S-02, SPT 6+3+3 REC=16", 89%	MC = 20.3% PP = 1.00 tsf	
4.0	FILL, sampled as lean clay with sand; moist, orangish- brown, trace gravel	FILL	2088.0			S-03, SPT 3+4+6 REC=12", 67%	MC = 31.6% PP = 3.00 tsf	Residual
5.5	FAT CLAY WITH SAND; moist, orangish- brown, trace gravel	CH	2086.5	B	5			

Bottom of Boring at 5.5 ft.
Boring terminated at selected depth.
Boring backfilled with cuttings upon completion.

APPENDIX B

LABORATORY TEST DATA

Summary of Laboratory Tests
Gradation Test Curves (2)
Consolidation Test Results (6 sheets)
Moisture Density Relation Test Curves (2)
California Bearing Ratio Test Curves (2)

Summary Of Laboratory Tests

Appendix
Sheet 1 of 1
Project Number: 22160136.000

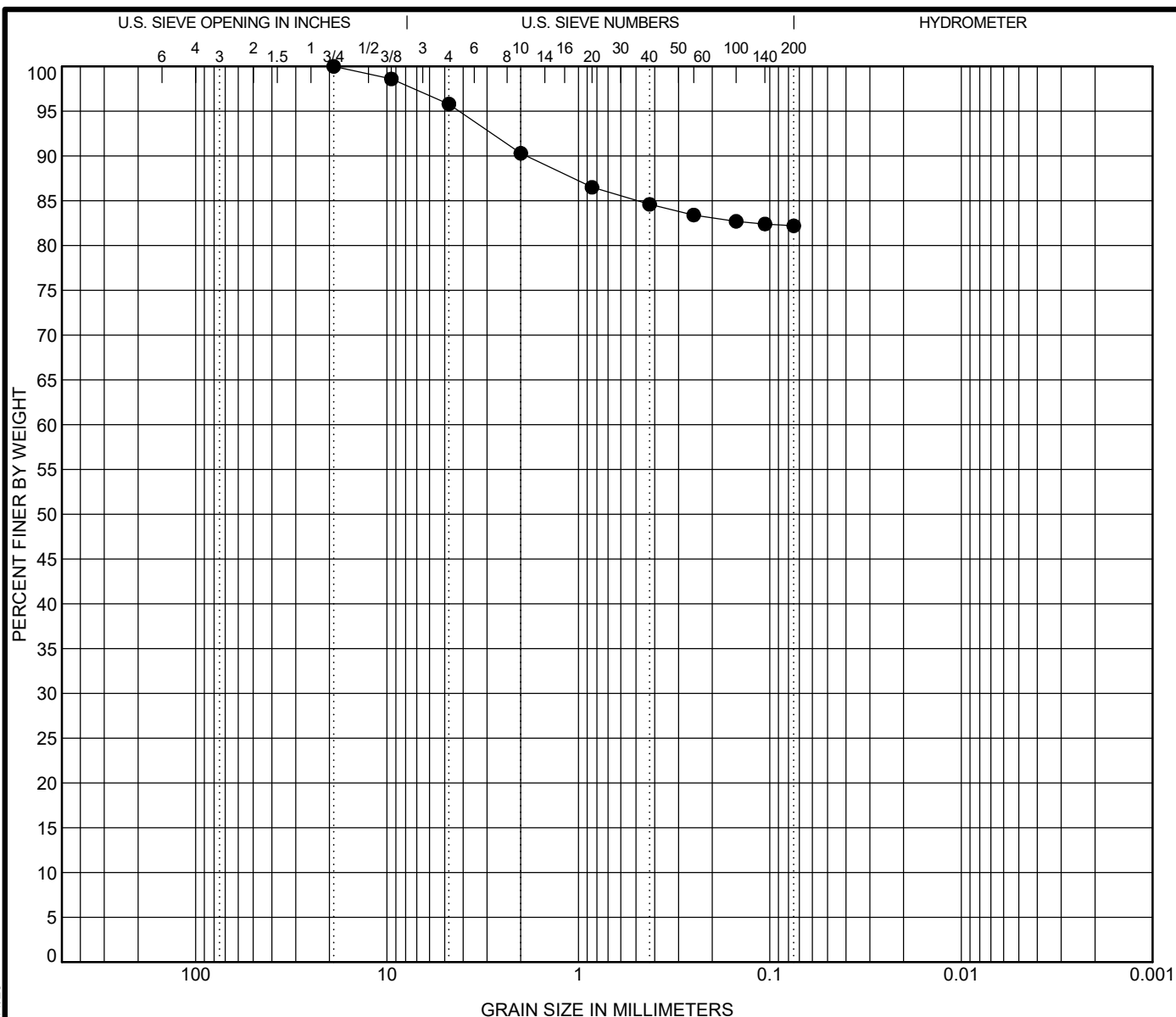
Boring No.	Sample Depth ft	Sample Type	Description of Soil Specimen	Wet Natural Density (pcf)	Natural Moisture (%)	Liquid Limit	Plasticity Index	% Passing No. 200 Sieve	Percent Sand	Percent Gravel	Specific Gravity	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Proctor Test Method	CBR Value	CBR Percent Swell	CBR Surcharge Pressure (psf)	pH	Resistivity (ohm-cm)	Oxidation Reduction Potential (mV)	Sulfides	Testing Laboratory
	Elevation ft																					
B-06	1.0 - 10.0	Bulk	FAT CLAY WITH SAND (CH), trace gravel, orangish brown	--	--	72	46	82.2	13.6	4.2	--	99.1	23.6	698A	5.8	0.6	50	--	--	--	--	BLAC
	2092.0 - 2083.0																					
B-07A	10.0 - 12.0	Tube	FAT CLAY (CH), trace sand, orangish brown	111.4	42.8	97	65	97.5	2.5	0.0	2.73	--	--	--	--	--	--	5.2	1200	357	ND	BLAC
	2084.0 - 2082.0																					
B-09	0.5 - 10.0	Bulk	FAT CLAY (CH), trace sand and gravel, orangish brown	--	--	76	46	93.2	4.8	2.0	--	95.4	25.9	698A	5.4	0.7	50	7.1	900	254	ND	BLAC
	2093.5 - 2084.0																					

Notes:

1. Soil tests in general accordance with ASTM and AASHTO standards.
2. Soil classifications are in general accordance with ASTM D2487(as applicable), based on testing indicated and visual classification.
3. Key to abbreviations: NP=Non-Plastic; -- indicates no test performed; ND=Not Detected



Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen	Sample Description					LL	PL	PI		
B-06 1.0 ft	FAT CLAY WITH SAND (CH), trace gravel, orangish brown					72	26	46		
Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
ASTM D422	19				4.2	13.6	82.2			

Percent Finer

Sieve Size	No. 200	No. 140	No. 100	No. 60	No. 40	No. 20	No. 10	No. 4	3/8 in.	3/4 in.
% Finer	82.2	82.4	82.7	83.4	84.6	86.5	90.3	95.8	98.6	100.0

Tested By	Tested Date	Reviewed By	Calc By
MJF	3/21/23	ACL	MJF



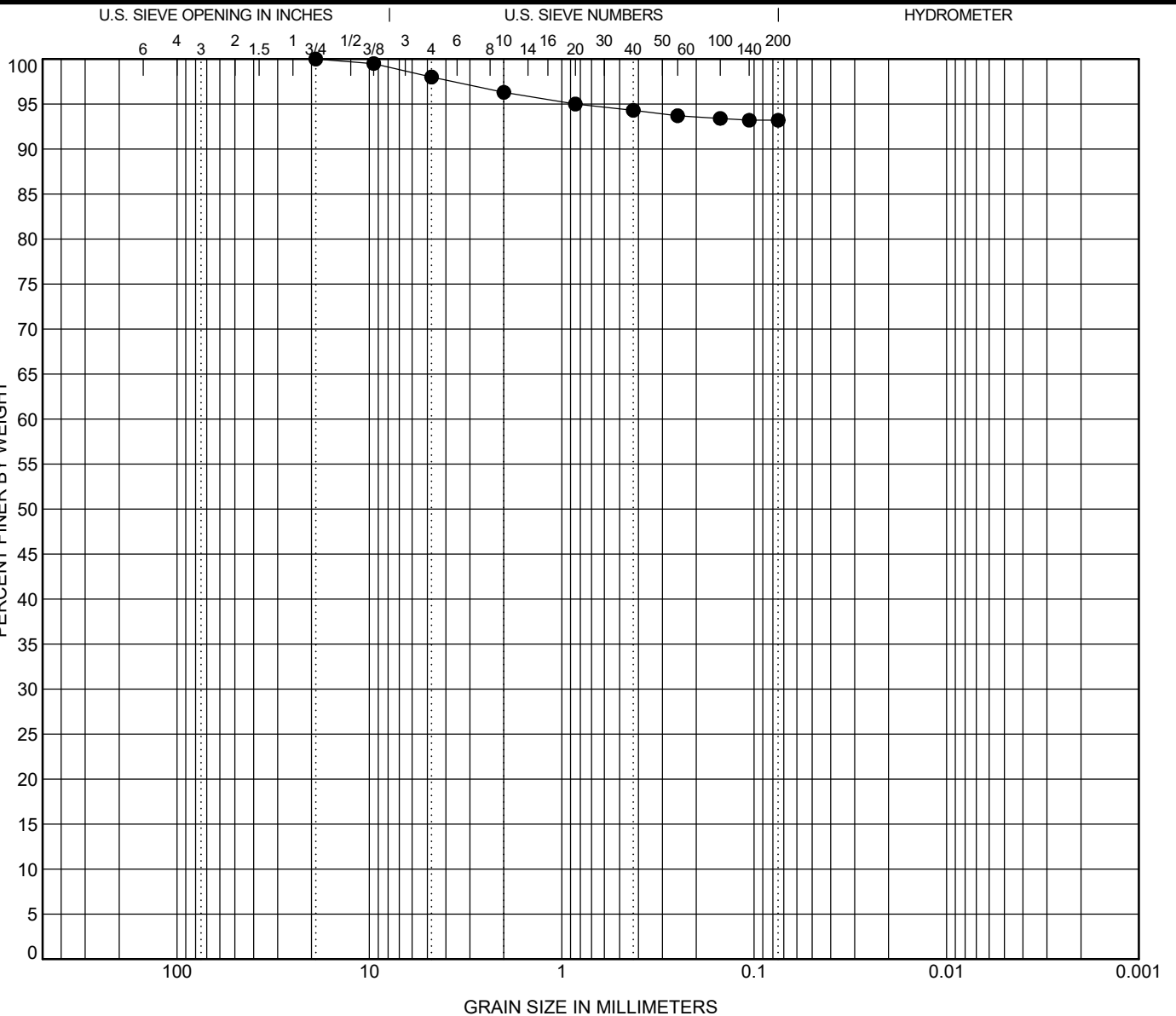
Schnabel
ENGINEERING

GRADATION CURVE

Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA

Contract: 22160136.000 **Testing Lab:** BLAC

PERCENT FINER BY WEIGHT



GRAIN SIZE IN MILLIMETERS

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen	Sample Description					LL	PL	PI		
B-09	0.5 ft	FAT CLAY (CH), trace sand and gravel, orangish brown					76	30	46	
Test Method	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
ASTM D422	19				2.0	4.8	93.2			

Percent Finer

Sieve Size	No. 200	No. 140	No. 100	No. 60	No. 40	No. 20	No. 10	No. 4	3/8 in.	3/4 in.
% Finer	93.2	93.2	93.4	93.7	94.3	95.0	96.3	98.0	99.5	100.0

Tested By	Tested Date	Reviewed By	Calc By
MJF	3/21/23	ACL	MJF

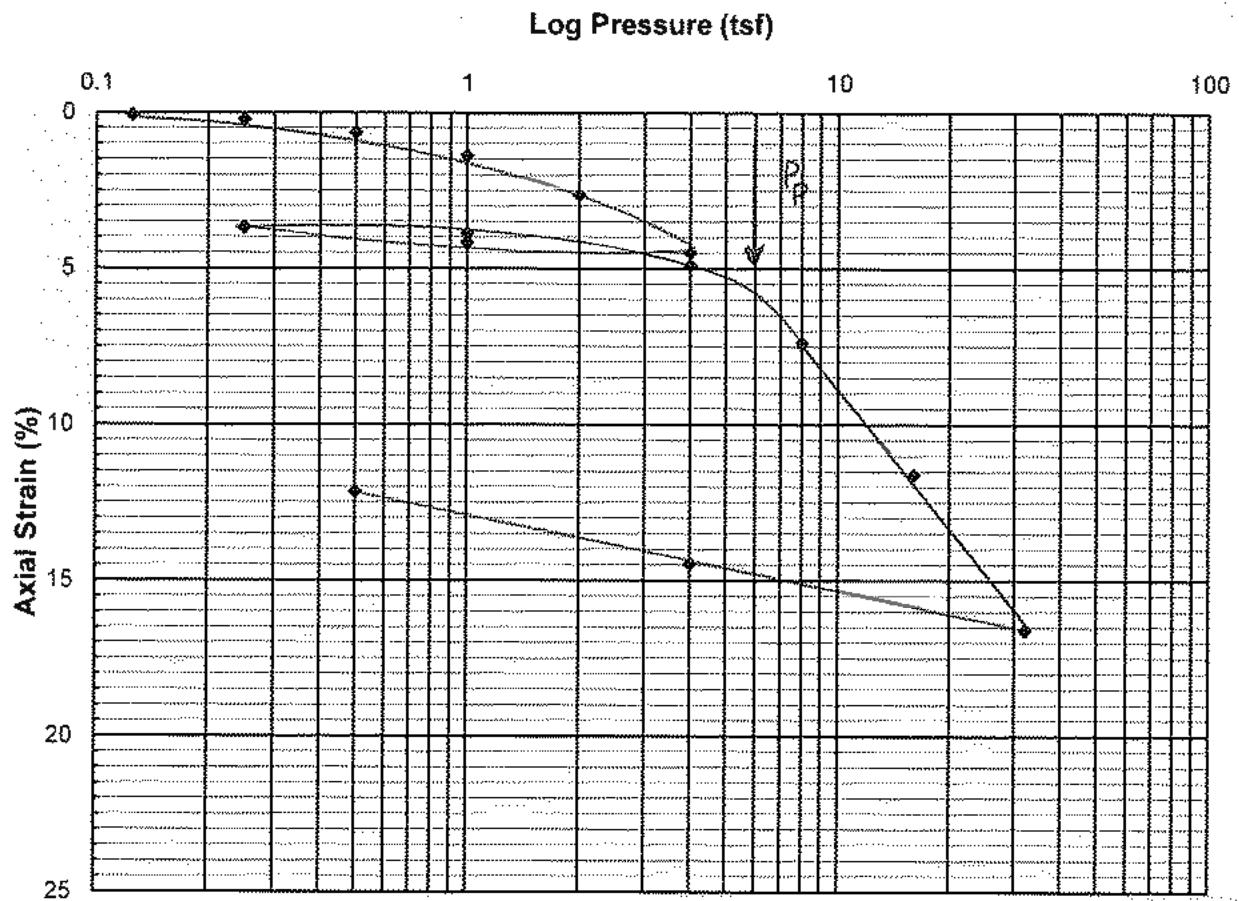


Schnabel
ENGINEERING


GRADATION CURVE

Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA

Contract: 22160136.000 **Testing Lab:** BLAC



Testing Lab: BLAC

Probable Preconsolidation Pressure (P_p), tsf: 6.0				Recompression Ratio (C_{er}): 0.010	
Type of Specimen: Tube Sample				Compression Ratio (C_{ec}): 0.153	
Description: FAT CLAY (CH), trace sand, orangish brown					
LL: 97	PI: 65	Gs: 2.73	P_o' (tsf): 0.61	Water Content, %	Initial 41.0 Final 33.7
% < No. 200: 97.5	Test Method: ASTM D2435 Method A			Void Ratio	1.15 0.89
Test Condition: inundated @ 0.05 tsf				Saturation, %	97 100
				Dry Unit Weight, pcf	79.2 90.2
Remarks:				Project: Montgomery County Magistrate and Court Services Building	
Average Water Content of Trimmings, %: 39.0				Location: Christiansburg, VA	
 Schnabel ENGINEERING				Boring: B-07A	Schnabel No.: 22160136
				Depth: 10-12 ft	Elevation: 2084-2082 ft.
				Date: 5/10/2023	Reviewed by: TTM
Consolidation Test Report					

Consolidation Test Data Sheet

Consolidometer ID: 1

5/10/23

Schnabel Contract: 22160136

Test Method: ASTM D2435 Method A

Project: Montgomery County

Test Condition: inundated @ 0.05 tsf Initial Height of Specimen (H_o), in.: 0.7480

Magistrate and Court Services Building

Height of Solids (H_s), in.: 0.3479

Boring No.: B-07A

Seating Press. (tsf): 0.05

Initial Dial Gauge Reading (D_o), in.: 0.0000

Depth: 10-12 ft.

Final Height Differential (H_d), in.: -0.0105

Reviewed by: TTM

Pressure, P (tsf)	Time Readings Required	Date Load Applied	Time Load Applied	Load Applied By	A	B	C	D	Vertical Strain ⁵ , ϵ_i (%)	Void Ratio ⁶ , e_i
					Final ¹ Dial Reading, D_{fi} $\times 10^{-4}$ in.	Apparatus Correction ² , D_{ci} $\times 10^{-4}$ in.	Cumulative Change in Height ³ , ΔH_i in.	Height of Voids ⁴ , H_{vi} in.		
0.125		4/12/2023	9:00	DWC	7	2	0.0005	0.3996	0.07	1.149
0.25		4/13/2023	9:00	DWC	22	6	0.0016	0.3985	0.21	1.146
0.5		4/14/2023	9:00	DWC	56	9	0.0047	0.3954	0.63	1.137
1		4/15/2023	9:00	DWC	118	15	0.0103	0.3898	1.38	1.121
2		4/17/2023	9:00	DWC	219	21	0.0198	0.3803	2.65	1.093
4		4/18/2023	9:00	DWC	370	35	0.0335	0.3666	4.48	1.054
1		4/19/2023	9:00	DWC	326	15	0.0311	0.3690	4.16	1.061
0.25		4/20/2023	9:00	DWC	281	6	0.0275	0.3726	3.68	1.071
1		4/21/2023	9:00	DWC	304	15	0.0289	0.3712	3.86	1.067
4		4/22/2023	9:00	DWC	398	32	0.0366	0.3635	4.89	1.045
8		4/24/2023	9:00	DWC	594	42	0.0552	0.3449	7.38	0.991
16		4/25/2023	9:00	DWC	920	52	0.0868	0.3133	11.60	0.901
32		4/26/2023	9:00	DWC	1304	63	0.1241	0.2760	16.59	0.793
4		4/27/2023	9:00	DWC	1114	32	0.1082	0.2919	14.47	0.839
0.5		4/28/2023	9:00	DWC	918	9	0.0909	0.3092	12.15	0.889

- Notes:
- "Final" based on test method; 24 hrs for Method A, end of primary for Method B.
 - Correction value, for the current pressure, from the consolidometer's calibration curve.
 - $\Delta H = D_{fi} - D_o - D_{ci} = \text{Col. A} - D_o - \text{Col. B}$
 - $H_{vi} = (H_o - H_s) - \Delta H$
 - $\epsilon_i = (\Delta H / H_o) \times 100 = (\text{Col. C} / H_o) \times 100$
 - $e_i = H_{vi} / H_s = \text{Col. D} / H_s$

Testing Lab: BLAC

Consol 5/2007 Rev. 6



Load Time Readings

5/10/23

Project: Montgomery County

Schnabel Contract: 22160136

Boring No.: B-07A

Depth: 10-12 ft.

Consol. ID: 1

Reviewed by: TTM

Test Drainage Conditions: Double

Elapsed Time (min.)	Dial Gauge Readings (inches)					
	1 tsf	32 tsf				
	Reload 4/19/2023	Load 4/26/2023				
0.1	0.0294	0.0992				
0.25	0.0295	0.1016				
0.5	0.0296	0.1040				
1	0.0297	0.1072				
2	0.0298	0.1128				
4	0.0299	0.1185				
8	0.0300	0.1223				
15	0.0301	0.1247				
30	0.0301	0.1263				
60	0.0302	0.1272				
120	0.0302	0.1280				
240	0.0303	0.1287				
480	0.0304	0.1295				
720	0.0304	0.1296				
960	0.0304	0.1301				
1200	0.0304	0.1303				
1440	0.0304	0.1304				
1680						
1920						
2160						
2400						
2640						
2880						



Consolidation Time Curves

5/10/23

Project: Montgomery County

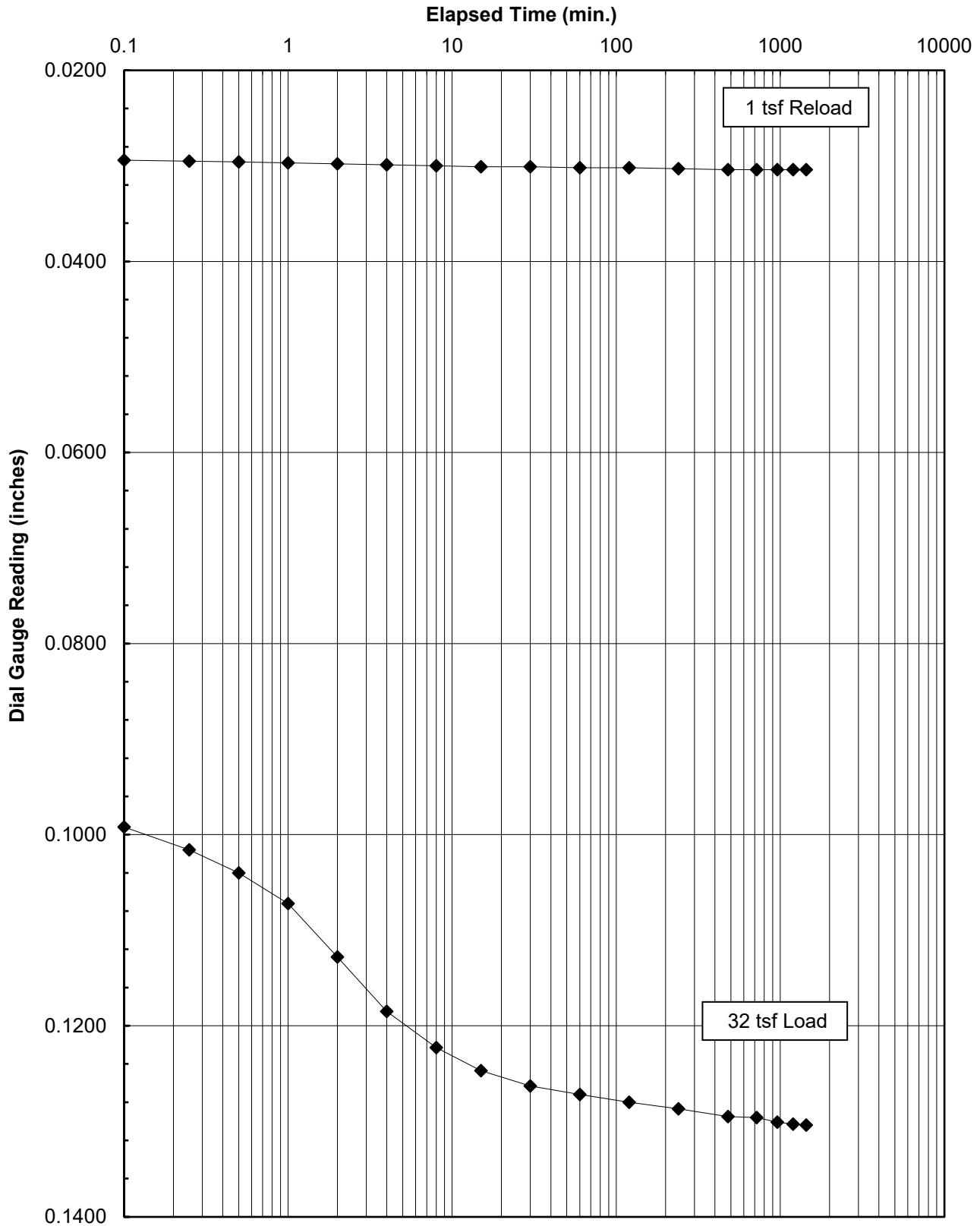
Schnabel Contract: 22160136

Boring No.: B-07A

Depth: 10-12 ft.

Reviewed by: TTM

Test Drainage Conditions: Double





Load Time Readings

5/10/23

Project: Montgomery County

Schnabel Contract: 22160136

Boring No.: B-07A

Depth: 10-12 ft.

Consol. ID: 1

Reviewed by: TTM

Test Drainage Conditions: Double

Elapsed Time (min.^0.5)	Dial Gauge Readings (inches)					
	1 tsf	32 tsf				
	Reload 4/19/2023	Load 4/26/2023				
0.3	0.0294	0.0992				
0.5	0.0295	0.1016				
0.7	0.0296	0.1040				
1.0	0.0297	0.1072				
1.4	0.0298	0.1128				
2.0	0.0299	0.1185				
2.8	0.0300	0.1223				
3.9	0.0301	0.1247				
5.5	0.0301	0.1263				
7.7	0.0302	0.1272				
11.0	0.0302	0.1280				
15.5	0.0303	0.1287				
21.9	0.0304	0.1295				
26.8	0.0304	0.1296				
31.0	0.0304	0.1301				
34.6	0.0304	0.1303				
37.9	0.0304	0.1304				
41.0						
43.8						
46.5						
49.0						
51.4						
53.7						



Consolidation Time Curves

5/10/23

Project: Montgomery County

Schnabel Contract: 22160136

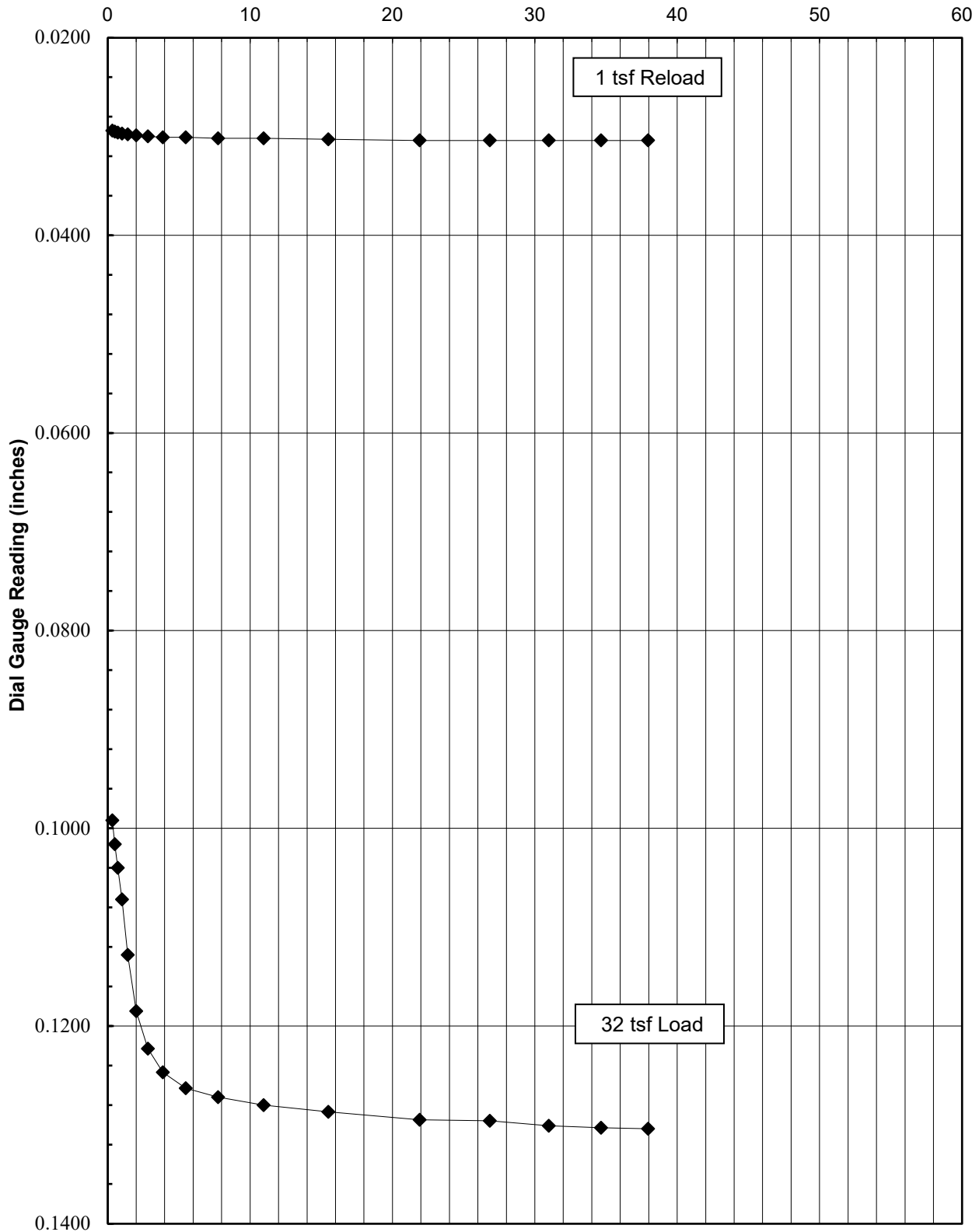
Boring No.: B-07A

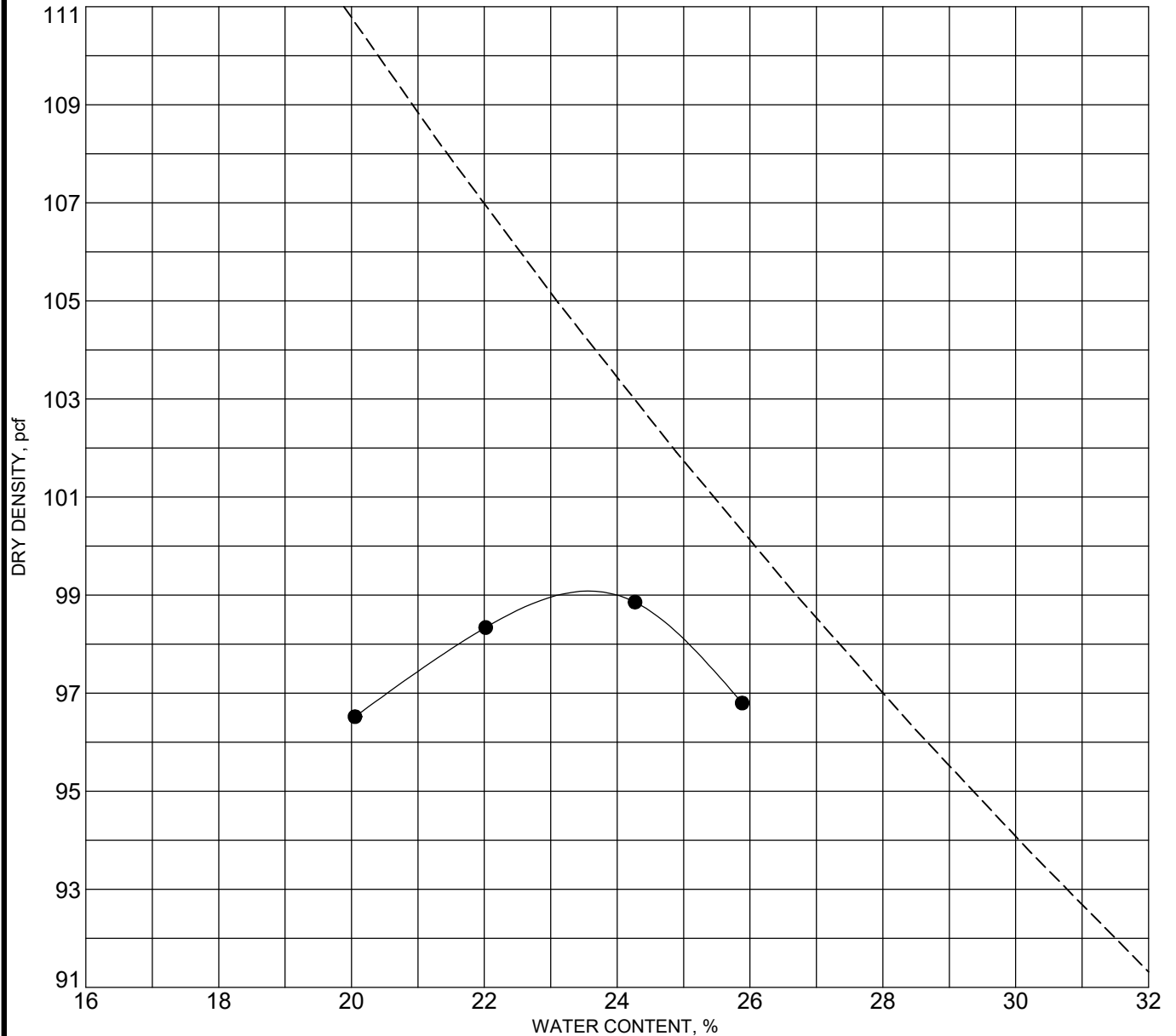
Depth: 10-12 ft.

Reviewed by: TTM

Test Drainage Conditions: Double

Elapsed Time (min.^{0.5})





Sample Description: FAT CLAY WITH SAND (CH), trace gravel, orangish brown

Sample Source: B-06, 1.0 ft

Test Methods: ASTM D698 Method A

Assumed Specific Gravity: 2.75

Max. Dry Density (pcf): 99.1

Opt. Moisture (%): 23.6

Liquid Limit (LL): 72

Plasticity Index (PI): 46

% Retained #4 Sieve: 4.2

% Passing # 200 Sieve: 82.2

Comments:

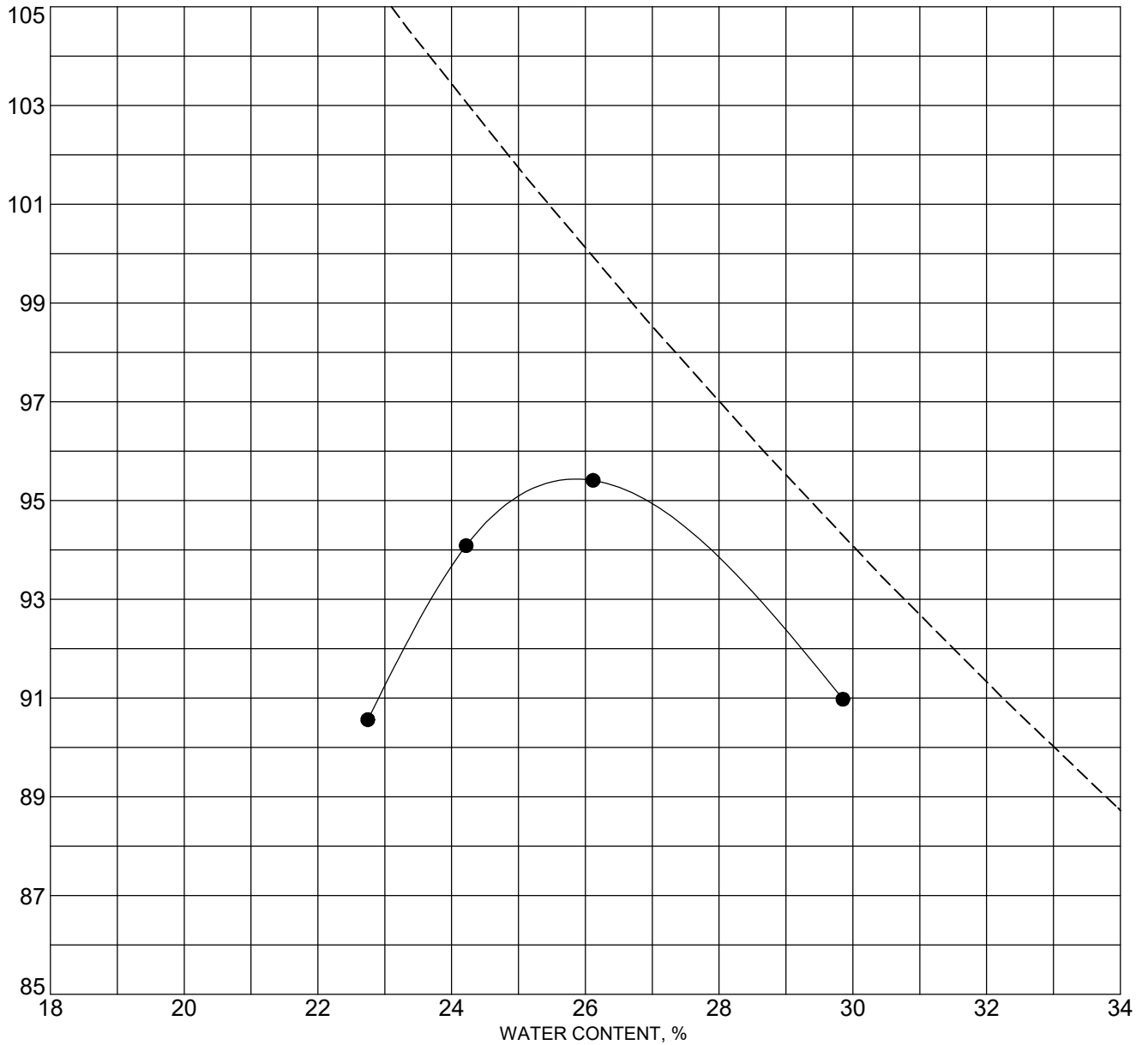


MOISTURE DENSITY RELATIONSHIP

Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA

Contract: 22160136.000 **Testing Lab:** BLAC

DRY DENSITY, pcf



Sample Description: FAT CLAY (CH), trace sand and gravel, orangish brown

Sample Source: B-09, 0.5 ft

Test Methods: ASTM D698 Method A

Assumed Specific Gravity: 2.75

Max. Dry Density (pcf): 95.4

Opt. Moisture (%): 25.9

Liquid Limit (LL): 76

Plasticity Index (PI): 46

% Retained #4 Sieve: 2.0

% Passing # 200 Sieve: 93.2

Comments:



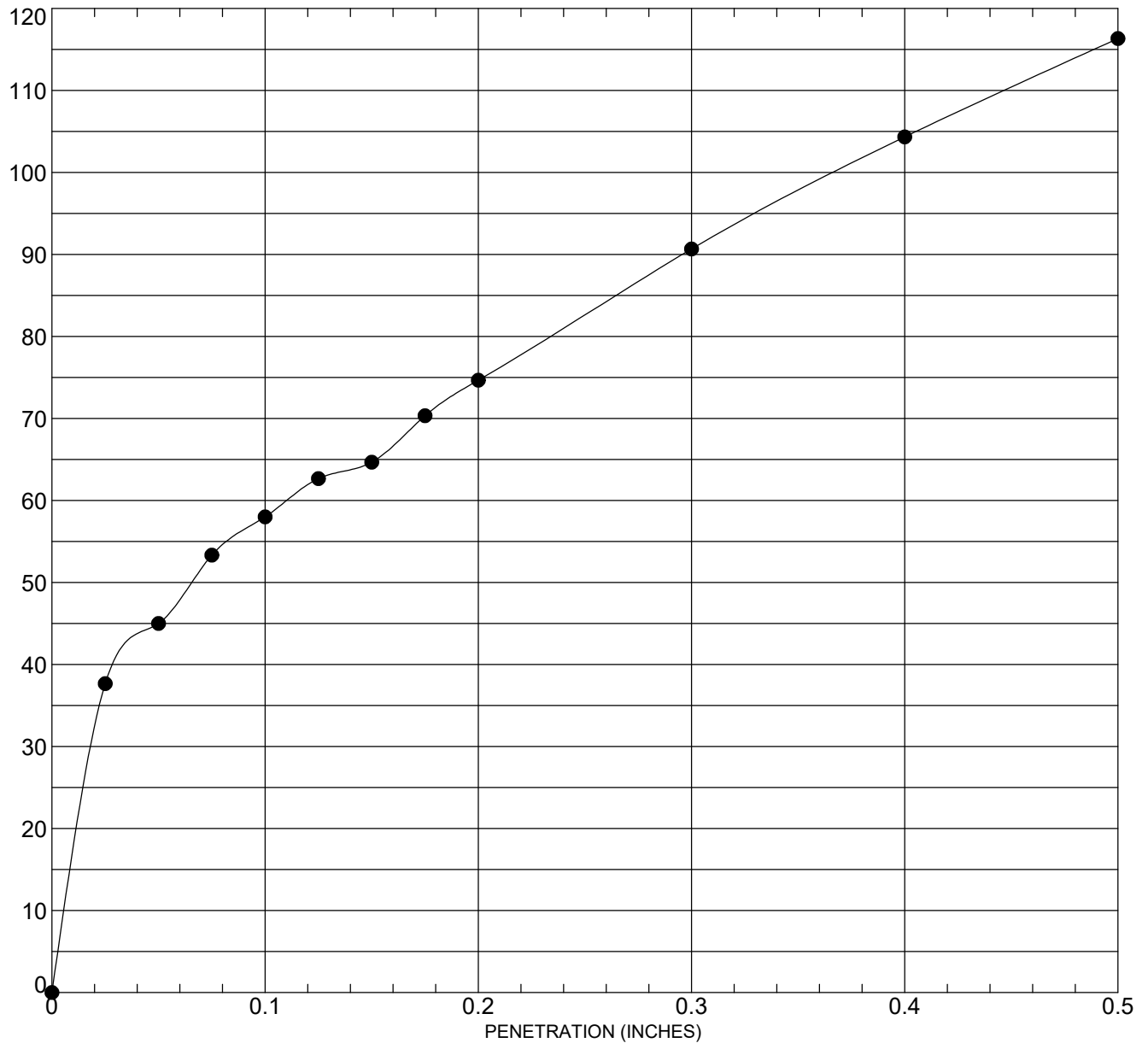
Schnabel
ENGINEERING

MOISTURE DENSITY RELATIONSHIP

Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA

Contract: 22160136.000 **Testing Lab:** BLAC

STRESS ON PISTON (psi)



PENETRATION (INCHES)

Sample Description: FAT CLAY WITH SAND (CH), trace
gravel, orangish brown

Sample Source: B-06

Sample Depth: 1.0 ft

Test Method: ASTM D1883

Liquid Limit (LL): 72

Plasticity Index (PI): 46

% Retained #4 Sieve: 4.2

% Passing # 200 Sieve: 82.2

Dry Density Before Soaking (pcf): 97.9

Dry Density After Soaking (pcf): 97.4

Maximum Dry Density (pcf): 99.1

Moisture Content Before Soaking (%): 23.1

Moisture Content After Soaking (Avg) (%): 25.1

Moisture Content Top Inch After Soak (%): 30.8

Optimum Moisture Content (%): 23.6

CBR: 5.8, Soaked

Surcharge (psf): 50

Swell (%): 0.6



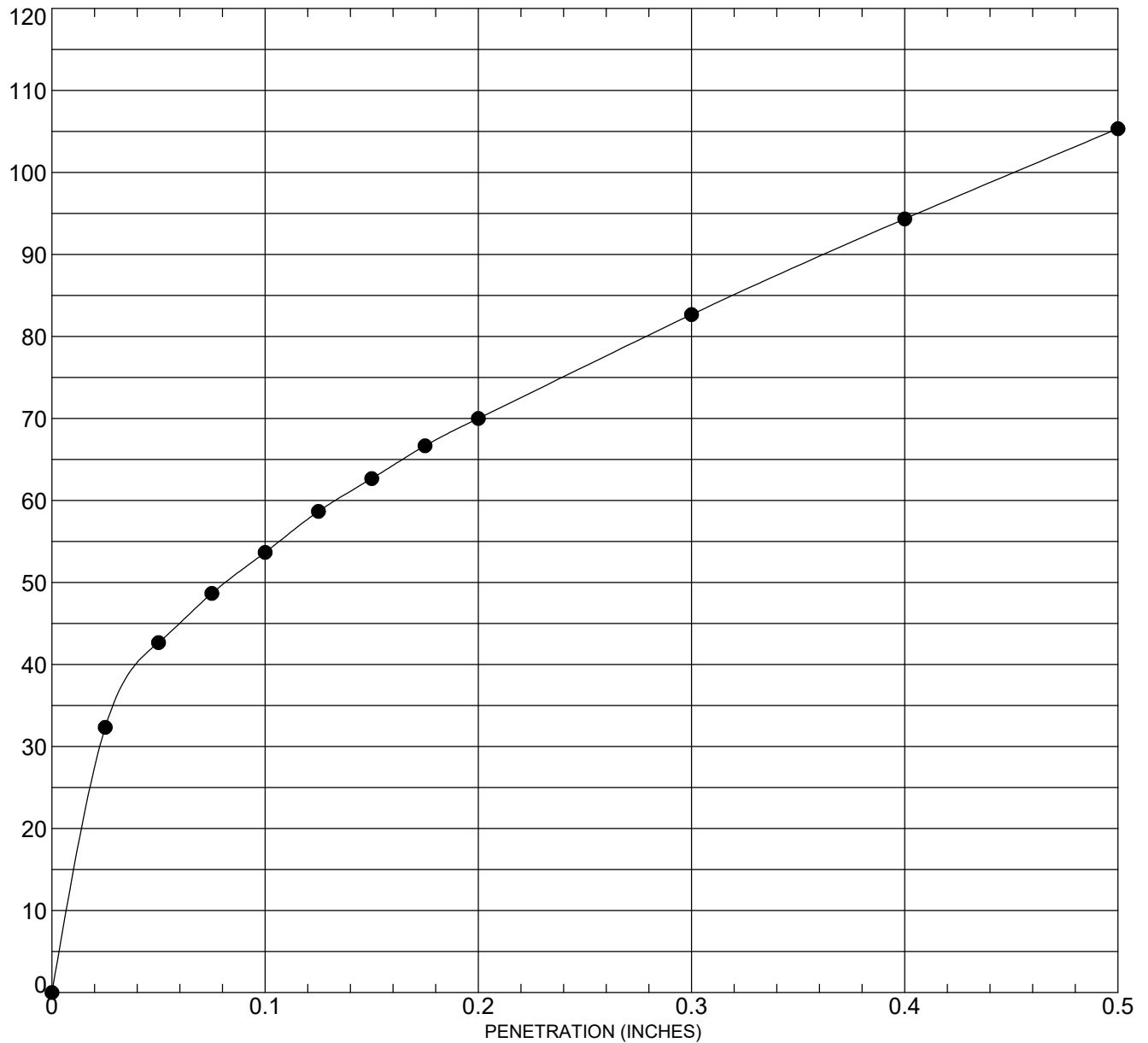
Schnabel
ENGINEERING

CALIFORNIA BEARING RATIO TEST

Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA

Contract: 22160136.000 **Testing Lab:** BLAC

STRESS ON PISTON (psi)



PENETRATION (INCHES)

Sample Description: FAT CLAY (CH), trace sand and gravel,
orangish brown

Sample Source: B-09
Sample Depth: 0.5 ft
Test Method: ASTM D1883

Liquid Limit (LL): 76
Plasticity Index (PI): 46
% Retained #4 Sieve: 2.0
% Passing # 200 Sieve: 93.2

Dry Density Before Soaking (pcf): 91.7
Dry Density After Soaking (pcf): 91.1
Maximum Dry Density (pcf): 95.4
Moisture Content Before Soaking (%): 25.7
Moisture Content After Soaking (Avg) (%): 28.7
Moisture Content Top Inch After Soak (%): 29.4
Optimum Moisture Content (%): 25.9

CBR: 5.4, Soaked
Surcharge (psf): 50
Swell (%): 0.7



Schnabel
ENGINEERING

CALIFORNIA BEARING RATIO TEST

Project: Montgomery County
Magistrate and Court Services Building
Christiansburg, VA

Contract: 22160136.000 **Testing Lab:** BLAC

APPENDIX B

Asbestos & Lead Inspection Report, dated July 21, 2023



Solutions for all your Environmental and OSHA Concerns

July 21, 2023

Asbestos & Lead Inspection Report

Project Location:

6 S Franklin Street,
Christiansburg, Virginia

Prepared For:

Montgomery County
755 Roanoke St
Christiansburg, VA 24073

Prepared By:

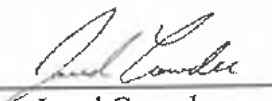

Jared Crowder
Asbestos Inspector
Lead Inspector

TABLE OF CONTENTS

SCOPE OF WORK

ASBESTOS INSPECTION

- **SAMPLE SUMMARY**
- **LABORATORY REPORT**

LEAD INSPECTION

- **LEAD BASED PAINT TESTING RESULTS**

PHOTOS

APPLICABLE LICENSES

Scope of Work

HDH Technical, Inc. was contracted by Montgomery County to provide an asbestos inspection and lead-based paint screening at structure located at 6 S Franklin Street, Christiansburg, Virginia. The inspection was conducted by personnel trained and licensed in accordance with the regulations of the Environmental Protection Agency (EPA) and the Commonwealth of Virginia. This inspection was performed using current EPA AHERA standards. This protocol was used for the determination, sampling and analysis of suspected Asbestos Containing Materials (ACM).

Also included in this report is a Lead-Based Paint Screening at this location. The term "screening" is used as opposed to "inspection" due to the fact that a complete HUD type paint inspection of each surface in every space was not performed. Generally speaking, each differing type of interior and exterior component and each differing type of paint was tested, although each component was not tested in each room. This "screening" will be referred to as an "inspection" throughout this report and was conducted in accordance with accepted industry standards and applicable regulations established by OSHA and the EPA. This inspection only identifies lead-based paint that is accessible through non-destructive methods. It does not identify lead-based paint materials located within walls, concrete decks, subfloors, or other generally inaccessible areas.

ASBESTOS INSPECTION

An inspection of 6 S Franklin Street was performed on January 31, 2023 & July 18, 2023 by representatives of HDHT. The objective of this inspection was to determine the location of asbestos-containing building materials (ACBM) currently located on the interior or exterior of this structure that may be disturbed in conjunction with upcoming renovation activities at this location.

The inspection was conducted by personnel trained and licensed in accordance with the regulations of the Environmental Protection Agency (EPA) and the Commonwealth of Virginia. This inspection meets the protocol outlined in current EPA AHERA regulations. This protocol was used for the determination, sampling and analysis of suspect asbestos containing materials.

As the sample summary indicates, the following suspect materials sampled were reported to be asbestos containing by the laboratory:

- **Window Framing Caulk – Original Wooden Framed Windows**
- **Silver Roof Coating on Parapet Wall**
 - This material may exist under metal on parapet wall
- **Asphaltic Roof Material Remnants – This material was found above the drop ceiling on the second floor**
- **Pipe Insulation - FRIABLE**
 - **THIS MATERIAL WAS FOUND IN THE CRAWLSPACE BUT MAY ALSO EXIST IN WALLS AND PIPE CHASES**
 - **THIS MATERIAL IS DAMAGED AND MAY CONTAMINATE SOIL IN CRAWLSPACE**

These NON-Friable / Friable (Pipe Insulation) asbestos containing materials should be removed prior to demolition activities at this location. Removal should be performed by licensed, contract personnel using approved methods.

Friable Asbestos Material: Material when dry, may be crumbled, pulverized or reduced to powder by hand pressure and includes previously non-friable material after such previously non-friable material becomes damaged to the extent that when dry is may be crumbled, pulverized, or reduced to powder by hand pressure.

Non-friable Asbestos Material: Material that contains asbestos in which the fibers have been locked in by a bonding agent, coating, binder, or other material so that the asbestos is well bound and will not release fibers during any appropriate use, handling, demolition, storage, transportation, processing or disposal.

This information should be provided to all contract personnel for their use in meeting current OSHA requirements. Every attempt was made to gain access to all areas or to assess representative materials entering or leaving the area. HDH Technical, Inc. accepts no liability nor makes any claims regarding ACBM which was not accessible during the inspection process if such material was located behind or within walls, concrete decks, subfloors, or was generally inaccessible without destructive sampling. If any additional suspect materials are identified during the course of the project, the contractor is to immediately stop work and contact the Owner for further direction.

Asbestos Sample Summary

6 S Franklin Street

LAB #	SAMPLE ID	SAMPLE DESCRIPTION	RESULT	%
23006297 -001	SR 1.1	Sheetrock	ND	-
23006297 -002	SR 1.2	Sheetrock	ND	-
23006297 -003	SR 1.3	Sheetrock	ND	-
23006297 -004	SR 1.4	Sheetrock	ND	-
23006297 -005	JC 2.1	Joint Compound	ND	-
23006297 -006	JC 2.2	Joint Compound	ND	-
23006297 -007	JC 2.3	Joint Compound	ND	-
23006297 -008	JC 2.4	Joint Compound	ND	-
23006297 -009	CT 3.1	Ceiling Tile - Rough Texture	ND	-
23006297 -010	CT 3.2	Ceiling Tile - Rough Texture	ND	-
23006297 -011	CT 3.3	Ceiling Tile - Rough Texture	ND	-
23006297 -012	CT 4.1	Ceiling Tile - Smooth Texture	ND	-
23006297 -013	CT 4.2	Ceiling Tile - Smooth Texture	ND	-
23006297 -014	CT 4.3	Ceiling Tile - Smooth Texture	ND	-
23006297 -015	BM 5.1	Baseboard Mastic - White	ND	-
23006297 -016	BM 5.2	Baseboard Mastic - White	ND	-
23006297 -017	FT 6.1	Floor Tile - 12x12 - Tan w Brown	ND	-
23006297 -018	FT 6.2	Floor Tile - 12x12 - Tan w Brown	ND	-
23006297 -019	TM 7.1	Tile Mastic - FT 6	ND	-
23006297 -020	TM 7.2	Tile Mastic - FT 6	ND	-
23006297 -021	FT 8.1	Floor Tile - 12x12 - White - Under Subfloor	ND	-
23006297 -022	FT 8.2	Floor Tile - 12x12 - White - Under Subfloor	ND	-
23006297 -023	TM 9.1	Tile Mastic - FT 8	ND	-
23006297 -024	TM 9.2	Tile Mastic - FT 8	ND	-
23006297 -025	LN 10.1	Linoleum - Tan	ND	-
23006297 -026	LN 10.2	Linoleum - Tan	ND	-
23006297 -027	LC 11.1	Leveling Compound - Under Carpet	ND	-
23006297 -028	LC 11.2	Leveling Compound - Under Carpet	ND	-
23006297 -029	BM 12.1	Baseboard Mastic - Brown	ND	-
23006297 -030	BM 12.2	Baseboard Mastic - Brown	ND	-
23006297 -031	LN 13.1	Linoleum - Squares - Mens Restroom	ND	-
23006297 -032	LN 13.2	Linoleum - Squares - Mens Restroom	ND	-

ND = NONE DETECTED

NA = NOT ANALYZED
POSITIVE STOP

■ = CHRYSOTILE

▲ = AMOSITE

● = OTHER

6 S Franklin Street

LAB #	SAMPLE ID	SAMPLE DESCRIPTION	RESULT	%
23006297 -033	SC 14.1	Skim Coat Plaster	ND	-
23006297 -034	SC 14.2	Skim Coat Plaster	ND	-
23006297 -035	SC 14.3	Skim Coat Plaster	ND	-
23006297 -036	SC 14.4	Skim Coat Plaster	ND	-
23006297 -037	BC 15.1	Base Coat Plaster	ND	-
23006297 -038	BC 15.2	Base Coat Plaster	ND	-
23006297 -039	BC 15.3	Base Coat Plaster	ND	-
23006297 -040	BC 15.4	Base Coat Plaster	ND	-
23006297 -041	TW 16.1	Textured Wall	ND	-
23006297 -042	TW 16.2	Textured Wall	ND	-
23006297 -043	TW 16.3	Textured Wall	ND	-
23006297 -044	PI 17.1	Aircell Pipe Insulation	■	50%
23006297 -045	PM 18.1	Pipe Mastic	ND	-
23006297 -046	PM 18.2	Pipe Mastic	ND	-
23006297 -047	.PM 18.3	Pipe Mastic	ND	-
23006297 -048	ES 19.1	End Sealer	ND	-
23006297 -049	ES 19.2	End Sealer	ND	-
23006297 -050	ES 19.3	End Sealer	ND	-
23006297 -051	FT 20.1	Floor Tile - 12x12 - Under Carpet/Subfloor	ND	-
23006297 -052	FT 20.2	Floor Tile - 12x12 - Under Carpet/Subfloor	ND	-
23006297 -053	TM 21.1	Tile Mastic - FT 20	ND	-
23006297 -054	TM 21.2	Tile Mastic - FT 20	ND	-
23006297 -055	DF 22.1	Door Framing - Interior	ND	-
23006297 -056	DF 22.2	Door Framing - Interior	ND	-
23006297 -057	FT 23.1	Floor Tile - 12x12 - White - Addition	ND	-
23006297 -058	FT 23.2	Floor Tile - 12x12 - White - Addition	ND	-
23006297 -059	TM 24.1	Tile Mastic - FT 23	ND	-
23006297 -060	TM 24.2	Tile Mastic - FT 23	ND	-
23006297 -061	RM 25.1	Roof Material	■	5%
23006297 -062	RM 25.2	Roof Material	■	5%
23006297 -063	DF 26.1	Door Framing - Steel Doors	ND	-
23006297 -064	DF 26.2	Door Framing - Steel Doors	ND	-

ND = NONE DETECTED

NA = NOT ANALYZED
POSITIVE STOP

■ = CHRYSOTILE

▲ = AMOSITE

● = OTHER

6 S Franklin Street

[illegible]

  **OTHER**

Laboratory Report



10501 Trade Ct., Suite 100
N. Chesterfield, VA 23139
804-897-1177 / 888-895-1175
Fax 804-897-0070
www.sanair.com

Asbestos
Chain of Custody

SanAir ID Number

23 006297

Company: HDH Technical, Inc		Project #: Montgomery County	Collected by: Crowder
Address: 1305 Radford Street		Project Name: 6 S Franklin St Christiansburg	Phone #: 540-381-7999
City, St, Zip: Christiansburg, VA 24073		Date Collected: 1/31/2023	Email: rlicha1@hdtassociates.com
State of Collection: VA Account #: 1769		P.O. Number:	Email: jcrowder@hdtassociates.com

Bulk		Air		Soil/Vermiculite	
ABB	PLM EPA 600/R-93/116 <input checked="" type="checkbox"/>	ABA	PCM NIOSH 7400 <input type="checkbox"/>	ABSE	PLM EPA 600/R-93/116 (Qual.) <input type="checkbox"/>
	Positive Stop <input type="checkbox"/>	ABA-2	OSHA w/ TWA* <input type="checkbox"/>	ABSP	PLM CARB 435 (LOD <1%) <input type="checkbox"/>
ABEPA	PLM EPA 400 Point Count <input type="checkbox"/>	ABTEM	TEM AHERA <input type="checkbox"/>	ABSP1	PLM CARB 435 (LOD 0.25%) <input type="checkbox"/>
ABB1K	PLM EPA 1000 Point Count <input type="checkbox"/>	ABATN	TEM NIOSH 7402 <input type="checkbox"/>	ABSP2	PLM CARB 435 (LOD 0.1%) <input type="checkbox"/>
ABBEN	PLM EPA NOB <input type="checkbox"/>	ABT2	TEM Level II <input type="checkbox"/>		
ABBCH	TEM Chatfield <input type="checkbox"/>				
ABBTM	TEM EPA NOB <input type="checkbox"/>				

Water		New York ELAP		Dust	
ABHE	EPA 100.2 <input type="checkbox"/>	PLM NY	PLM EPA 600/M4-82-020 <input type="checkbox"/>	ABWA	TEM Wipe ASTM D-8480 <input type="checkbox"/>
		ABEPA2	NY ELAP 198.1 <input type="checkbox"/>	ABDMV	TEM Microvac ASTM D-5755 <input type="checkbox"/>
		ABENY	NY ELAP 198.6 PLM NOB <input type="checkbox"/>		
		ABBNY	NY ELAP 198.4 TEM NOB <input type="checkbox"/>	Matrix	Other <input type="checkbox"/>

Turn Around Times	3 HR (4 HR TEM) <input type="checkbox"/>	6 HR (8HR TEM) <input type="checkbox"/>	12 HR <input type="checkbox"/>	24 HR <input checked="" type="checkbox"/>
	2 Days <input type="checkbox"/>	3 Days <input type="checkbox"/>	4 Days <input type="checkbox"/>	5 Days <input type="checkbox"/>

Special Instructions:	
-----------------------	--

SAMPLE ID	SAMPLE DESCRIPTION
SR 1.1	Sheetrock
SR 1.2	Sheetrock
SR 1.3	Sheetrock
SR 1.4	Sheetrock
JC 2.1	Joint Compound
JC 2.2	Joint Compound
JC 2.3	Joint Compound
JC 2.4	Joint Compound
CT 3.1	Ceiling Tile - Rough Texture
CT 3.2	Ceiling Tile - Rough Texture
CT 3.3	Ceiling Tile - Rough Texture

Special Instructions	
----------------------	--

Relinquished by	Date	Time	Received by	Date	Time
Crowder	1/31/2023	3:00 PM	UPS	2/1/23	3:00 PM

Unless scheduled, the turn around time for all samples received after 3 pm EST Friday will begin at 8 am Monday morning. Weekend or Holiday work must be scheduled ahead of time and is charged for rush turn around time. Work with standard turn around time sent Priority Overnight and billed to Recipient will be charged a \$10 shipping fee.

23006297

SAMPLE ID	SAMPLE DESCRIPTION
CT 4.1	Ceiling Tile - Smooth Texture
CT 4.2	Ceiling Tile - Smooth Texture
CT 4.3	Ceiling Tile - Smooth Texture
BM 5.1	Baseboard Mastic - White
BM 5.2	Baseboard Mastic - White
FT 6.1	Floor Tile - 12x12 - Tan w Brown
FT 6.2	Floor Tile - 12x12 - Tan w Brown
TM 7.1	Tile Mastic - FT 6
TM 7.2	Tile Mastic - FT 6
FT 8.1	Floor Tile - 12x12 - White - Under Subfloor
FT 8.2	Floor Tile - 12x12 - White - Under Subfloor
TM 9.1	Tile Mastic - FT 8
TM 9.2	Tile Mastic - FT 8
LN 10.1	Linoleum - Tan
LN 10.2	Linoleum - Tan
LC 11.1	Leveling Compound - Under Carpet
LC 11.2	Leveling Compound - Under Carpet
BM 12.1	Baseboard Mastic - Brown
BM 12.2	Baseboard Mastic - Brown
LN 13.1	Linoleum - Squares - Mens Restroom
LN 13.2	Linoleum - Squares - Mens Restroom
SC 14.1	Skim Coat Plaster
SC 14.2	Skim Coat Plaster
SC 14.3	Skim Coat Plaster
SC 14.4	Skim Coat Plaster
BC 15.1	Base Coat Plaster
BC 15.2	Base Coat Plaster

Relinquished by	Date	Time	Received by	Date	Time
Crowder	1/31/2023	3:00 PM	UPS AK	1/31/2023 2/1/23	3:00 PM 9:35 AM

Unless scheduled, the turn around time for all samples received after 3 pm EST Friday will begin at 8 am Monday morning. Weekend or Holiday work must be scheduled ahead of time and is charged for rush turn around time. Work with standard turn around time sent Priority Overnight and Billed to Recipient will be charged a \$10 shipping fee.

23006297

SAMPLE ID	SAMPLE DESCRIPTION
BC 15.3	Base Coat Plaster
BC 15.4	Base Coat Plaster
TW 16.1	Textured Wall
TW 16.2	Textured Wall
TW 16.3	Textured Wall
PI 17.1	Aircell Pipe Insulation
PM 18.1	Pipe Mastic
PM 18.2	Pipe Mastic
PM 18.3	Pipe Mastic
ES 19.1	End Sealer
ES 19.2	End Sealer
ES 19.3	End Sealer
FT 20.1	Floor Tile - 12x12 - Under Carpet/Subfloor
FT 20.2	Floor Tile - 12x12 - Under Carpet/Subfloor
TM 21.1	Tile Mastic - FT 20
TM 21.2	Tile Mastic - FT 20
DF 22.1	Door Framing - Interior
DF 22.2	Door Framing - Interior
FT 23.1	Floor Tile - 12x12 - White - Addition
FT 23.2	Floor Tile - 12x12 - White - Addition
TM 24.1	Tile Mastic - FT 23
TM 24.2	Tile Mastic - FT 23
RM 25.1	Roof Material
RM 25.2	Roof Material
DF 26.1	Door Framing - Steel Doors
DF 26.2	Door Framing - Steel Doors
LF 27.1	Louver Framing

Special Instructions	
----------------------	--

Relinquished by	Date	Time	Received by	Date	Time
Crowder	1/31/2023	3:00 PM	UPS	1/31/2023	3:00 PM
			<i>AK</i>	2/1/23	9:55 PM

Unless scheduled, the turn around time for all samples received after 3 pm EST Friday will begin at 8 am Monday morning. Weekend or Holiday work must be scheduled ahead of time and is charged for rush turn around time. Work with standard turn around time sent Priority Overnight and billed to Recipient will be charged a \$10 shipping fee.

Page 3 of 4



SanAir ID Number
23006297
FINAL REPORT
2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
SR 1.1 / 23006297-001 Sheetrock	White Non-Fibrous Homogeneous	3% Cellulose	97% Other	None Detected
SR 1.2 / 23006297-002 Sheetrock	White Non-Fibrous Homogeneous	3% Cellulose	97% Other	None Detected
SR 1.3 / 23006297-003 Sheetrock	White Non-Fibrous Homogeneous	3% Cellulose	97% Other	None Detected
SR 1.4 / 23006297-004 Sheetrock	White Non-Fibrous Homogeneous	3% Cellulose	97% Other	None Detected
JC 2.1 / 23006297-005 Joint Compound	White Non-Fibrous Homogeneous		100% Other	None Detected
JC 2.2 / 23006297-006 Joint Compound	White Non-Fibrous Homogeneous		100% Other	None Detected
JC 2.3 / 23006297-007 Joint Compound	White Non-Fibrous Homogeneous		100% Other	None Detected
JC 2.4 / 23006297-008 Joint Compound	White Non-Fibrous Homogeneous		100% Other	None Detected
CT 3.1 / 23006297-009 Ceiling Tile - Rough Texture	White Fibrous Homogeneous	45% Cellulose 20% Glass	35% Other	None Detected
CT 3.2 / 23006297-010 Ceiling Tile - Rough Texture	White Fibrous Homogeneous	45% Cellulose 20% Glass	35% Other	None Detected

Analyst:

Susan P. Childress

Approved Signatory:

Sandra Sobrius

Analysis Date: 2/2/2023

Date: 2/2/2023



SanAir ID Number

23006297

FINAL REPORT

2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
CT 3.3 / 23006297-011 Ceiling Tile - Rough Texture	White Fibrous Homogeneous	45% Cellulose 20% Glass	35% Other	None Detected
CT 4.1 / 23006297-012 Ceiling Tile - Smooth Texture	White Fibrous Homogeneous	55% Cellulose 20% Glass	25% Other	None Detected
CT 4.2 / 23006297-013 Ceiling Tile - Smooth Texture	White Fibrous Homogeneous	55% Cellulose 20% Glass	25% Other	None Detected
CT 4.3 / 23006297-014 Ceiling Tile - Smooth Texture	White Fibrous Homogeneous	55% Cellulose 20% Glass	25% Other	None Detected
BM 5.1 / 23006297-015 Baseboard Mastic	White Non-Fibrous Homogeneous		100% Other	None Detected
BM 5.2 / 23006297-016 Baseboard Mastic	White Non-Fibrous Homogeneous		100% Other	None Detected
FT 6.1 / 23006297-017 Floor Tile - 12x12				Not Submitted
FT 6.2 / 23006297-018 Floor Tile - 12x12	Tan Non-Fibrous Homogeneous		100% Other	None Detected
TM 7.1 / 23006297-019 Tile Mastic - FT 6	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
TM 7.2 / 23006297-020 Tile Mastic - FT 6				Not Submitted

Analyst:

Susan P. Childress

Approved Signatory:

Sandra Sobrin

Analysis Date: 2/2/2023

Date: 2/2/2023



SanAir ID Number
23006297
FINAL REPORT
2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
FT 8.1 / 23006297-021 Floor Tile - 12x12 - Under Subfloor	White Non-Fibrous Homogeneous		100% Other	None Detected
FT 8.2 / 23006297-022 Floor Tile - 12x12 - Under Subfloor	White Non-Fibrous Homogeneous		100% Other	None Detected
TM 9.1 / 23006297-023 Tile Mastic - FT 8	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
TM 9.2 / 23006297-024 Tile Mastic - FT 8	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
LN 10.1 / 23006297-025 Linoleum	Tan Non-Fibrous Heterogeneous	20% Cellulose	80% Other	None Detected
LN 10.2 / 23006297-026 Linoleum	Tan Non-Fibrous Heterogeneous	20% Cellulose	80% Other	None Detected
LC 11.1 / 23006297-027 Leveling Compound - Under Carpet	White Non-Fibrous Homogeneous		100% Other	None Detected
LC 11.2 / 23006297-028 Leveling Compound - Under Carpet	White Non-Fibrous Homogeneous		100% Other	None Detected
BM 12.1 / 23006297-029 Baseboard Mastic	Brown Non-Fibrous Homogeneous		100% Other	None Detected
BM 12.2 / 23006297-030 Baseboard Mastic	Brown Non-Fibrous Homogeneous		100% Other	None Detected

Analyst: *Susan P. Childress*

Approved Signatory:

Date: 2/2/2023

Analysis Date: 2/2/2023

Sandra Sobrin



SanAir ID Number

23006297

FINAL REPORT

2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
LN 13.1 / 23006297-031 Linoleum - Squares - Mens Restroom, Linoleum	Cream Non-Fibrous Heterogeneous	20% Cellulose	80% Other	None Detected
LN 13.1 / 23006297-031 Linoleum - Squares - Mens Restroom, Mastic	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
LN 13.2 / 23006297-032 Linoleum - Squares - Mens Restroom, Linoleum	Cream Non-Fibrous Heterogeneous	20% Cellulose	80% Other	None Detected
LN 13.2 / 23006297-032 Linoleum - Squares - Mens Restroom, Mastic	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.1 / 23006297-033 Skim Coat Plaster, Skim Coat	Beige Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.1 / 23006297-033 Skim Coat Plaster, Texture	White Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.2 / 23006297-034 Skim Coat Plaster, Skim Coat	Beige Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.2 / 23006297-034 Skim Coat Plaster, Texture	White Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.3 / 23006297-035 Skim Coat Plaster, Skim Coat	Beige Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.3 / 23006297-035 Skim Coat Plaster, Texture	White Non-Fibrous Homogeneous		100% Other	None Detected

Analyst:

Susan P. Childress

Approved Signatory:

Sandra Sobrin

Analysis Date: 2/2/2023

Date: 2/2/2023



SanAir ID Number
23006297
FINAL REPORT
2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
SC 14.4 / 23006297-036 Skim Coat Plaster, Skim Coat	Beige Non-Fibrous Homogeneous		100% Other	None Detected
SC 14.4 / 23006297-036 Skim Coat Plaster, Texture	White Non-Fibrous Homogeneous		100% Other	None Detected
BC 15.1 / 23006297-037 Base Coat Plaster	Grey Non-Fibrous Homogeneous	< 1% Hair	100% Other	None Detected
BC 15.2 / 23006297-038 Base Coat Plaster	Grey Non-Fibrous Homogeneous	< 1% Hair	100% Other	None Detected
BC 15.3 / 23006297-039 Base Coat Plaster	Grey Non-Fibrous Homogeneous	< 1% Hair	100% Other	None Detected
BC 15.4 / 23006297-040 Base Coat Plaster	Grey Non-Fibrous Homogeneous	< 1% Hair	100% Other	None Detected
TW 16.1 / 23006297-041 Textured Wall	White Non-Fibrous Homogeneous		100% Other	None Detected
TW 16.2 / 23006297-042 Textured Wall	White Non-Fibrous Homogeneous		100% Other	None Detected
TW 16.3 / 23006297-043 Textured Wall	White Non-Fibrous Homogeneous		100% Other	None Detected
PI 17.1 / 23006297-044 Aircell Pipe Insulation	Grey Fibrous Homogeneous	35% Cellulose	15% Other	50% Chrysotile

Analyst: *Susan P. Childress*

Approved Signatory:

Sandra Sobrin

Analysis Date: 2/2/2023

Date: 2/2/2023



SanAir ID Number

23006297

FINAL REPORT

2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
PM 18.1 / 23006297-045 Pipe Mastic	Beige Non-Fibrous Homogeneous		100% Other	None Detected
PM 18.2 / 23006297-046 Pipe Mastic	Beige Non-Fibrous Homogeneous		100% Other	None Detected
PM 18.3 / 23006297-047 Pipe Mastic	Beige Non-Fibrous Homogeneous		100% Other	None Detected
ES 19.1 / 23006297-048 End Sealer	White Non-Fibrous Homogeneous	15% Cellulose 2% Glass	83% Other	None Detected
ES 19.2 / 23006297-049 End Sealer	White Non-Fibrous Homogeneous	15% Cellulose 2% Glass	83% Other	None Detected
ES 19.3 / 23006297-050 End Sealer	White Non-Fibrous Homogeneous	15% Cellulose 2% Glass	83% Other	None Detected
FT 20.1 / 23006297-051 Floor Tile - 12x12 - Under Carpet/ Subfloor	Beige Non-Fibrous Homogeneous		100% Other	None Detected
FT 20.2 / 23006297-052 Floor Tile - 12x12 - Under Carpet/ Subfloor	Beige Non-Fibrous Homogeneous		100% Other	None Detected
TM 21.1 / 23006297-053 Tile Mastic - FT 20	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
TM 21.2 / 23006297-054 Tile Mastic - FT 20	Yellow Non-Fibrous Homogeneous		100% Other	None Detected

Analyst: *Susan P. Childress*

Approved Signatory:

Date: 2/2/2023

Analysis Date: 2/2/2023

Sandra Asbrink



SanAir ID Number
23006297
FINAL REPORT
2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
DF 22.1 / 23006297-055 Door Framing - Interior	White Non-Fibrous Homogeneous		100% Other	None Detected
DF 22.2 / 23006297-056 Door Framing - Interior	White Non-Fibrous Homogeneous		100% Other	None Detected
FT 23.1 / 23006297-057 Floor Tile - 12x12 - Addition	White Non-Fibrous Homogeneous		100% Other	None Detected
FT 23.2 / 23006297-058 Floor Tile - 12x12 - Addition	White Non-Fibrous Homogeneous		100% Other	None Detected
TM 24.1 / 23006297-059 Tile Mastic - FT 23	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
TM 24.2 / 23006297-060 Tile Mastic - FT 23	Yellow Non-Fibrous Homogeneous		100% Other	None Detected
RM 25.1 / 23006297-061 Roof Material, Tar	Black Non-Fibrous Homogeneous	3% Cellulose	97% Other	< 1% Chrysotile
RM 25.1 / 23006297-061 Roof Material, Felt	Black Non-Fibrous Heterogeneous	45% Cellulose	55% Other	None Detected
RM 25.1 / 23006297-061 Roof Material, Tar Paper	Black Non-Fibrous Heterogeneous	30% Cellulose	65% Other	5% Chrysotile
RM 25.2 / 23006297-062 Roof Material, Tar	Black Non-Fibrous Homogeneous	3% Cellulose	97% Other	< 1% Chrysotile

Analyst:

Susan P. Childress

Approved Signatory:

Sandra Sobieraj

Analysis Date: 2/2/2023

Date: 2/2/2023



SanAir ID Number

23006297

FINAL REPORT

2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
RM 25.2 / 23006297-062 Roof Material, Felt	Black Non-Fibrous Heterogeneous	45% Cellulose	55% Other	None Detected
RM 25.2 / 23006297-062 Roof Material, Tar Paper	Black Non-Fibrous Heterogeneous	30% Cellulose	65% Other	5% Chrysotile
DF 26.1 / 23006297-063 Door Framing - Steel Doors	Brown Non-Fibrous Homogeneous		100% Other	None Detected
DF 26.2 / 23006297-064 Door Framing - Steel Doors				Not Submitted
LF 27.1 / 23006297-065 Louwer Framing	White Non-Fibrous Homogeneous		100% Other	None Detected
LF 27.2 / 23006297-066 Louwer Framing	White Non-Fibrous Homogeneous		100% Other	None Detected
EJ 28.1 / 23006297-067 Expansion Joint	Grey Non-Fibrous Homogeneous		100% Other	None Detected
EJ 28.2 / 23006297-068 Expansion Joint	Grey Non-Fibrous Homogeneous		100% Other	None Detected
WF 29.1 / 23006297-069 Window Framing	White Non-Fibrous Homogeneous		100% Other	None Detected
WF 29.2 / 23006297-070 Window Framing	White Non-Fibrous Homogeneous		100% Other	None Detected

Analyst:

Susan P. Childress

Approved Signatory:

Sandra Asbrink

Analysis Date: 2/2/2023

Date: 2/2/2023



SanAir ID Number
23006297
FINAL REPORT
2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Analyst: Childress, Susan

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
WF 30.1 / 23006297-071 Window Framing	Black Non-Fibrous Homogeneous		100% Other	None Detected
WF 30.2 / 23006297-072 Window Framing	Black Non-Fibrous Homogeneous		100% Other	None Detected
WG 31.1 / 23006297-073 Window Glazing	White Non-Fibrous Homogeneous		100% Other	None Detected
WG 31.2 / 23006297-074 Window Glazing	White Non-Fibrous Homogeneous		100% Other	None Detected
DF 32.1 / 23006297-075 Door Framing - Wood Frames	White Non-Fibrous Homogeneous		100% Other	None Detected
DF 32.2 / 23006297-076 Door Framing - Wood Frames	White Non-Fibrous Homogeneous		100% Other	None Detected

Analyst: *Susan P. Childress*

Approved Signatory:

Date: 2/2/2023

Analysis Date: 2/2/2023

Disclaimer

This report is the sole property of the client named on the SanAir Technologies Laboratory chain-of-custody (COC). Results in the report are confidential information intended only for the use by the customer listed on the COC. Neither results nor reports will be discussed with or released to any third party without our client's written permission. The final report shall not be reproduced except in full without written approval of the laboratory to assure that parts of the report are not taken out of context. The information provided in this report applies only to the samples submitted and is relevant only for the date, time, and location of sampling. The accuracy of the results is dependent upon the client's sampling procedure and information provided to the laboratory by the client. SanAir assumes no responsibility for the sampling procedure and will provide evaluation reports based solely on the sample(s) in the condition in which they arrived at the laboratory and information provided by the client on the COC, such as: project number, project name, collection dates, po number, special instructions, samples collected by, sample numbers, sample identifications, sample type, selected analysis type, flow rate, total volume or area, and start stop times that may affect the validity of the results in this report. Samples were received in good condition unless otherwise noted on the report. SanAir assumes no responsibility or liability for the manner in which the results are used or interpreted. This report does not constitute and shall not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any other U.S. governmental agencies and may not be certified by every local, state, and federal regulatory agencies.

Samples are held for a period of 60 days. Fibers smaller than 5 microns cannot be seen with this method due to scope limitations.

For NY state samples, method EPA 600/M4-82-020 is performed.

NYELAP Disclaimer:

Polarized- light microscopy is not consistently reliable in detecting asbestos in floor covering and similar non-friable organically bound materials. Quantitative transmission electron microscopy is currently the only method that can be used to determine if this material can be considered or treated as non-asbestos containing.

Asbestos Certifications

NVLAP lab code 200870-0

City of Philadelphia: ALL-460

PA Department of Environmental Protection Number: 68-05397

California License Number: 2915

Colorado License Number: AL-23143

Connecticut License Number: PH-0105

Massachusetts License Number: AA000222

Maine License Number: LB-0075, LA-0084

New York ELAP lab ID: 11983

Rhode Island License Number: PCM00126, PLM00126, TEM00126

Texas Department of State Health Services License Number: 300440

Commonwealth of Virginia 3333000323

Washington State License Number: C989

West Virginia License Number: LT000616

Vermont License: AL166318

Louisiana Department of Environmental Quality: 212253, Cert 05088

Revision Date: 8/14/2020



SanAir ID Number

23006297

FINAL REPORT

2/2/2023 1:03:27 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 1/31/2023
Received Date: 2/1/2023 9:55:00 AM

Dear Crowder,

We at SanAir would like to thank you for the work you recently submitted. The 76 sample(s) were received on Wednesday, February 01, 2023 via UPS. The final report(s) is enclosed for the following sample(s): SR 1.1, SR 1.2, SR 1.3, SR 1.4, JC 2.1, JC 2.2, JC 2.3, JC 2.4, CT 3.1, CT 3.2, CT 3.3, CT 4.1, CT 4.2, CT 4.3, BM 5.1, BM 5.2, FT 6.2, TM 7.1, FT 8.1, FT 8.2, TM 9.1, TM 9.2, LN 10.1, LN 10.2, LC 11.1, LC 11.2, BM 12.1, BM 12.2, LN 13.1, LN 13.2, SC 14.1, SC 14.2, SC 14.3, SC 14.4, BC 15.1, BC 15.2, BC 15.3, BC 15.4, TW 16.1, TW 16.2, TW 16.3, PI 17.1, PM 18.1, PM 18.2, PM 18.3, ES 19.1, ES 19.2, ES 19.3, FT 20.1, FT 20.2, TM 21.1, TM 21.2, DF 22.1, DF 22.2, FT 23.1, FT 23.2, TM 24.1, TM 24.2, RM 25.1, RM 25.2, DF 26.1, LF 27.1, LF 27.2, EJ 28.1, EJ 28.2, WF 29.1, WF 29.2, WF 30.1, WF 30.2, WG 31.1, WG 31.2, DF 32.1, DF 32.2. The following sample(s) were unusable and were not tested: FT 6.1, TM 7.2, DF 26.2

These results only pertain to this job and should not be used in the interpretation of any other job. This report is only complete in its entirety. Refer to the listing below of the pages included in a complete final report.

Sincerely,

Sandra Sobrino
Asbestos & Materials Laboratory Manager
SanAir Technologies Laboratory

Final Report Includes:

- Cover Letter
- Analysis Pages
- Disclaimers and Additional Information

Sample conditions:

- 73 samples in Good condition.
- 3 samples in Sample Not Received condition. (#17, #20, #64)



10501 Trade Ct., Suite 100
N. Chesterfield, VA 23139
804-897-1177 / 888-895-1175
Fax 804-897-0070
www.sanair.com

**Asbestos
Chain of Custody**

SanAir ID Number

230385-95

Company: HDH Technical, Inc	Project #: Montgomery County	Collected by: Crowder
Address: 1305 Radford Street	Project Name: 6 S Franklin St Christiansburg	Phone #: 540-381-7999
City, St, Zip: Christiansburg, VA 24073	Date Collected: 7/18/2023	Email: rtiebal@hdhassociates.com
State of Collection: VA Account #: 1769	P.O. Number:	Email: jcrowder@hdhassociates.com

Bulk			Air			Soil/Vermiculite		
ABB	PLM EPA 600/R-93/118	<input checked="" type="checkbox"/>	ABA	PCM NIOSH 7400	<input type="checkbox"/>	ABSE	PLM EPA 600/R-93/118 (Qual.)	<input type="checkbox"/>
	Positive Stop	<input type="checkbox"/>	ABA-2	OSHA w/ TWA*	<input type="checkbox"/>	ABSP	PLM CARB 435 (LOD <1%)	<input type="checkbox"/>
ABEPA	PLM EPA 400 Point Count	<input type="checkbox"/>	ABTEM	TEM AHERA	<input type="checkbox"/>	ABSP1	PLM CARB 435 (LOD 0.25%)	<input type="checkbox"/>
ABB1K	PLM EPA 1000 Point Count	<input type="checkbox"/>	ABATN	TEM NIOSH 7402	<input type="checkbox"/>	ABSP2	PLM CARB 435 (LOD 0.1%)	<input type="checkbox"/>
ABBEN	PLM EPA NOB	<input type="checkbox"/>	ABT2	TEM Level II	<input type="checkbox"/>			
ABBCH	TEM Chatfield	<input type="checkbox"/>						
ABOTM	TEM EPA NOB	<input type="checkbox"/>						

Water			New York ELAP			Dust		
ABHE	EPA 100.2	<input type="checkbox"/>	PLM NY	PLM EPA 600/M4-82-020	<input type="checkbox"/>	ABWA	TEM Wipe ASTM D-6480	<input type="checkbox"/>
			ABEPA2	NY ELAP 198.1	<input type="checkbox"/>	ABOMV	TEM Microvac ASTM D-5755	<input type="checkbox"/>
			ABENY	NY ELAP 198.6 PLM NOB	<input type="checkbox"/>			
			ABBNY	NY ELAP 198.4 TEM NOB	<input type="checkbox"/>			

Turn Around Times		3 HR (4 HR TEM)		6 HR (8HR TEM)		12 HR		24 HR	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Matrix		Other	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Special Instructions:

SAMPLE ID	SAMPLE DESCRIPTION
-----------	--------------------

VB 1.1	Vapor Barrier - Upper Roof
VB 1.2	Vapor Barrier - Upper Roof
CK 2.1	Caulk - Parapet - Upper Roof
CK 2.2	Caulk - Parapet - Upper Roof
RC 3.1	Roof Cement - Upper Roof
RC 3.2	Roof Cement - Upper Roof
RC 4.1	Roof Cement - Lower Roof
RC 4.2	Roof Cement - Lower Roof
WF 5.1	Window Framing
WF 5.2	Window Framing

Special Instructions

Relinquished by	Date	Time	Received by	Date	Time
Crowder	7/18/2023	12:41 PM	UPS	7/18/2023	12:41 PM
			Sh	7/19/23	10:45 am

Unless scheduled, the turn around time for all samples received after 3 pm EST Friday will begin at 8 am Monday morning. Weekend or Holiday work must be scheduled ahead of time and is charged for rush turn around time. Work with standard turn around time sent Priority Overnight and Billed to Recipient will be charged a \$10 shipping fee.



SanAir ID Number
23038595
FINAL REPORT
7/20/2023 12:23:00 PM

Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 7/18/2023
Received Date: 7/19/2023 10:45:00 AM

Analyst: Williams, Darien

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
VB 1.1 / 23038595-001 Vapor Barrier - Upper Roof	Black Fibrous Homogeneous	65% Cellulose	35% Other	None Detected
VB 1.2 / 23038595-002 Vapor Barrier - Upper Roof	Black Fibrous Homogeneous	65% Cellulose	35% Other	None Detected
CK2.1 / 23038595-003 Caulk - Parapet - Upper Roof	Various Non-Fibrous Homogeneous		100% Other	None Detected
CK2.2 / 23038595-004 Caulk - Parapet - Upper Roof, Caulk	Various Non-Fibrous Heterogeneous		100% Other	None Detected
CK2.2 / 23038595-004 Caulk - Parapet - Upper Roof, Paint	Silver Non-Fibrous Homogeneous		98% Other	2% Chrysotile
RC 3.1 / 23038595-005 Roof Cement - Upper Roof	Black Non-Fibrous Homogeneous	2% Cellulose	98% Other	None Detected
RC 3.2 / 23038595-006 Roof Cement - Upper Roof	Black Non-Fibrous Heterogeneous		100% Other	None Detected
RC 4.1 / 23038595-007 Roof Cement -Lower Roof	Black Non-Fibrous Homogeneous		100% Other	None Detected
RC 4.2 / 23038595-008 Roof Cement -Lower Roof	Black Non-Fibrous Heterogeneous		100% Other	None Detected
WF 5.1 / 23038595-009 Window Framing	White Non-Fibrous Homogeneous		97% Other	3% Chrysotile

Analyst: *Darien Williams*

Approved Signatory:

Sandra Asbrink

Analysis Date: 7/20/2023

Date: 7/20/2023



SanAir ID Number

23038595

FINAL REPORT

7/20/2023 12:23:00 PM

Name: HDH Technical, Inc.

Address: P.O. Box 6158

Christiansburg, VA 24073

Phone: 540-381-7999

Project Number: Montgomery County

P.O. Number:

Project Name: 6 S Franklin St Christiansburg

Collected Date: 7/18/2023

Received Date: 7/19/2023 10:45:00 AM

Analyst: Williams, Darien

Asbestos Bulk PLM EPA 600/R-93/116

SanAir ID / Description	Stereoscopic	Components		Asbestos Fibers
	Appearance	% Fibrous	% Non-fibrous	
WF 5.2 / 23038595-010 Window Framing	White Non-Fibrous Homogeneous		97% Other	3% Chrysotile

Analyst:

Approved Signatory:

Analysis Date: 7/20/2023

Date: 7/20/2023



Name: HDH Technical, Inc.
Address: P.O. Box 6158
Christiansburg, VA 24073
Phone: 540-381-7999

SanAir ID Number
23038595
FINAL REPORT
7/20/2023 12:23:00 PM

Project Number: Montgomery County
P.O. Number:
Project Name: 6 S Franklin St Christiansburg
Collected Date: 7/18/2023
Received Date: 7/19/2023 10:45:00 AM

Dear Crowder,

We at SanAir would like to thank you for the work you recently submitted. The 10 sample(s) were received on Wednesday, July 19, 2023 via UPS. The final report(s) is enclosed for the following sample(s): VB 1.1, VB 1.2, CK2.1, CK2.2, RC 3.1, RC 3.2, RC 4.1, RC 4.2, WF 5.1, WF 5.2.

These results only pertain to this job and should not be used in the interpretation of any other job. This report is only complete in its entirety. Refer to the listing below of the pages included in a complete final report.

Sincerely,

A handwritten signature in black ink that reads "Sandra Sobrino". The signature is written in a cursive, flowing style.

Sandra Sobrino
Asbestos & Materials Laboratory Manager
SanAir Technologies Laboratory

Final Report Includes:

- Cover Letter
- Analysis Pages
- Disclaimers and Additional Information

Sample conditions:

- 10 samples in Good condition.

Disclaimer

This report is the sole property of the client named on the SanAir Technologies Laboratory chain-of-custody (COC). Results in the report are confidential information intended only for the use by the customer listed on the COC. Neither results nor reports will be discussed with or released to any third party without our client's written permission. The final report shall not be reproduced except in full without written approval of the laboratory to assure that parts of the report are not taken out of context. The information provided in this report applies only to the samples submitted and is relevant only for the date, time, and location of sampling. The accuracy of the results is dependent upon the client's sampling procedure and information provided to the laboratory by the client. SanAir assumes no responsibility for the sampling procedure and will provide evaluation reports based solely on the sample(s) in the condition in which they arrived at the laboratory and information provided by the client on the COC, such as: project number, project name, collection dates, po number, special instructions, samples collected by, sample numbers, sample identifications, sample type, selected analysis type, flow rate, total volume or area, and start stop times that may affect the validity of the results in this report. Samples were received in good condition unless otherwise noted on the report. SanAir assumes no responsibility or liability for the manner in which the results are used or interpreted. This report does not constitute and shall not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any other U.S. governmental agencies and may not be certified by every local, state, and federal regulatory agencies.

Samples are held for a period of 60 days. Fibers smaller than 5 microns cannot be seen with this method due to scope limitations.

For NY state samples, method EPA 600/M4-82-020 is performed.

NYELAP Disclaimer:

Polarized- light microscopy is not consistently reliable in detecting asbestos in floor covering and similar non-friable organically bound materials. Quantitative transmission electron microscopy is currently the only method that can be used to determine if this material can be considered or treated as non-asbestos containing.

Asbestos Certifications

NVLAP lab code 200870-0

City of Philadelphia: ALL-460

PA Department of Environmental Protection Number: 68-05397

California License Number: 2915

Colorado License Number: AL-23143

Connecticut License Number: PH-0105

Massachusetts License Number: AA000222

Maine License Number: LB-0075, LA-0084

New York ELAP lab ID: 11983

Rhode Island License Number: PCM00126, PLM00126, TEM00126

Texas Department of State Health Services License Number: 300440

Commonwealth of Virginia 3333000323

Washington State License Number: C989

West Virginia License Number: LT000616

Vermont License: AL166318

Louisiana Department of Environmental Quality: 212253, Cert 05088

Revision Date: 8/14/2020

LEAD INSPECTION

On July 18, 2023 a Lead-Based Paint inspection was also conducted at 6 S Franklin Street. The inspection was conducted to identify potential lead-based paint concerns involved in this renovation project. The areas were inspected by Jared Crowder.

The inspection determined that the following surfaces tested contain lead greater than or equal to 1.0 mg/cm, and are considered to be lead-based paint surfaces as defined by the Virginia Department of Professional and Occupational Regulation (DPOR) and the Environmental Protection Agency (EPA):

- **ALL ORIGINAL EXTERIOR COMPONENTS & SURFACES PAINTED WHITE**

LEAD COMPONENT:

For informational purposes, the following material was sampled and identified to be a lead component. Although not included in the Virginia Lead-based Paint Activities Regulations, the contractor should be provided this information in the event it is removed for disposal purposes:

- **Yellow Wall Tile in Front Restroom**

If lead is present, regardless of quantity, OSHA regulations are applicable. All persons involved in the disturbance of lead based or lead containing painted surfaces should be adequately trained to do so. All contractors should be provided with the results for their use in meeting current OSHA requirements for the protection of their workers and the environment.

This inspection was in compliance with the Virginia Lead-based Paint Activities Regulations, October 1, 1995. The Inspector is properly trained, licensed, and met the competency requirements spelled out in those regulations.

FIELD VERIFICATION

Jared Crowder, licensed lead-based paint inspector, inspected the structure on July 18, 2023.

A total of fifty-three (53) X-Ray Florescence (XRF) readings, including calibrations, were taken in substantial conformance with industry standards and other applicable federal and state regulations.

Jared Crowder's Virginia Lead Inspector license number is 3355001118.

A complete copy of all tested surfaces and results are included in this report. All positive samples are listed in BOLD.

HDH Technical, Inc. (HDHT) used the Heuresis Corporation model Pb200i (Serial#1609) X-Ray Fluorescence (XRF) instrument for the screening. This unit was resourced in February 2020. The instrument is not substrate dependent according to that performance characteristic sheet, so no substrate corrections were required during this screening.

The XRF was calibrated prior to use and at the end of the testing, or every four hours, whichever came first. All calibrations were conducted on a 1.10 ± 0.1 mg/cm² NIST SRM paint film. All calibrations are noted on the x-ray fluorescence data sheets.

For the purposes of this inspection lead-based paint is defined as greater than or equal to 1.0 mg/cm². The Heuresis Corporation instrument (model Pb200i) used in this survey have published threshold values of 1.0 mg/cm² on all substrates and do not require substrate correction. Paint chip confirmation of inconclusive samples was not necessary since no inconclusive surfaces were identified during sampling with this X-ray Fluorescence Analyzer. Lastly, this report detailing the findings of the inspection report was written to document the inspection and provide a permanent record of the evaluation.

Qualifications

The inspection was conducted by Jared Crowder, Licensed Lead Inspector #3355001118. The inspection was conducted in accordance with applicable Local, State, and Federal regulations.

Methodologies

This inspection was conducted in accordance with accepted industry standards and applicable regulations established by OSHA and the EPA. This inspection only identifies lead-based paint that is accessible through non-destructive methods. It does not identify lead-based paint materials located within walls, concrete decks, subfloors, or other generally inaccessible areas.

Disclaimer

This inspection report is written for and intended for the use of the Owner and its representatives only. HDHT is not responsible nor will be held liable for any interpretation made, opinions formed, or conclusions drawn by any third party as a result of examining the lab results, inspection results or this report. Any interpretations, opinions, and conclusions will be those made, formed, and drawn solely by that third party.

A lead inspector/risk assessor properly trained by a training institution utilizing an approved HUD curriculum and subsequently licensed to perform inspections by the Commonwealth of Virginia performed the inspection of this structure. HDHT accepts no liability nor makes any claims regarding lead based painted surfaces which were not tested and lead -based painted surfaces which were not accessible during the inspection process if such material was located behind or within walls, concrete decks, sub-floors, chases, or was otherwise generally inaccessible without destructive sampling.

Lead Based Paint Testing Results



1305 Radford Street

Christiansburg, Virginia 24073

Telephone: (540) 381-7999

Lead Testing for Construction

Montgomery County
6 S Franklin Street
Christiansburg, Virginia

READING	CONCENTRATION	UNITS	RESULTS	DATE	TIME	USER	SITE	ROOM CHOICE	STRUCTURE	MEMBER	SUBSTRATE	CONDITION
1	0	mg/cm2	Negative	07/18/23	10:18:26	HDHT	6 S Franklin St	Calibration				
2	1	mg/cm2	Positive	07/18/23	10:18:28	HDHT	6 S Franklin St	Calibration				
3	0.1	mg/cm2	Negative	07/18/23	10:18:26	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
4	0.3	mg/cm2	Negative	07/18/23	10:18:40	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
5	0.1	mg/cm2	Negative	07/18/23	10:18:57	HDHT	6 S Franklin St	Interior	Room	Chair Rail	Wood	Intact
6	0.2	mg/cm2	Negative	07/18/23	10:19:13	HDHT	6 S Franklin St	Interior	Room	Baseboard	Wood	Intact
7	0	mg/cm2	Negative	07/18/23	10:19:29	HDHT	6 S Franklin St	Interior	Door		Wood	Intact
8	0.1	mg/cm2	Negative	07/18/23	10:19:42	HDHT	6 S Franklin St	Interior	Door	Casing	Wood	Intact
9	0.1	mg/cm2	Negative	07/18/23	10:19:56	HDHT	6 S Franklin St	Interior	Door	Casing	Wood	Intact
10	0.2	mg/cm2	Negative	07/18/23	10:20:14	HDHT	6 S Franklin St	Interior	Room	Wall	Plaster	Intact
11	0.1	mg/cm2	Negative	07/18/23	10:20:24	HDHT	6 S Franklin St	Interior	Room	Wall	Plaster	Intact
12	0	mg/cm2	Negative	07/18/23	10:20:46	HDHT	6 S Franklin St	Interior	Window		Metal	Intact
13	0.1	mg/cm2	Negative	07/18/23	10:21:01	HDHT	6 S Franklin St	Interior	Room	Wall	Plaster	Intact
14	3.4	mg/cm2	Positive	07/18/23	10:21:11	HDHT	6 S Franklin St	Interior	Room	Wall	Tile	Intact
15	0.1	mg/cm2	Negative	07/18/23	10:21:37	HDHT	6 S Franklin St	Interior	Room	Wall	Plaster	Intact
16	0.1	mg/cm2	Negative	07/18/23	10:21:55	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
17	0.1	mg/cm2	Negative	07/18/23	10:22:17	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
18	0.1	mg/cm2	Negative	07/18/23	10:22:57	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
19	0.1	mg/cm2	Negative	07/18/23	10:23:11	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
20	0.5	mg/cm2	Negative	07/18/23	10:23:20	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
21	0	mg/cm2	Negative	07/18/23	10:23:43	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
22	0	mg/cm2	Negative	07/18/23	10:24:15	HDHT	6 S Franklin St	Interior	Door		Metal	Intact
23	0	mg/cm2	Negative	07/18/23	10:24:25	HDHT	6 S Franklin St	Interior	Door	Casing	Metal	Intact
24	0.1	mg/cm2	Negative	07/18/23	10:24:39	HDHT	6 S Franklin St	Interior	Door		Wood	Intact
25	0	mg/cm2	Negative	07/18/23	10:24:59	HDHT	6 S Franklin St	Interior	Door	Casing	Wood	Intact
26	0	mg/cm2	Negative	07/18/23	10:25:15	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
27	0.2	mg/cm2	Negative	07/18/23	10:25:34	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
28	0.1	mg/cm2	Negative	07/18/23	10:25:47	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
29	1	mg/cm2	Positive	07/18/23	10:26:44	HDHT	6 S Franklin St	Exterior	Window		Metal	Intact
30	0	mg/cm2	Negative	07/18/23	10:28:13	HDHT	6 S Franklin St	Interior	Stair		Wood	Intact
31	0.1	mg/cm2	Negative	07/18/23	10:28:32	HDHT	6 S Franklin St	Interior	Stair		Wood	Intact
32	0	mg/cm2	Negative	07/18/23	10:29:34	HDHT	6 S Franklin St	Interior	Stair		Wood	Intact
33	0.3	mg/cm2	Negative	07/18/23	10:29:49	HDHT	6 S Franklin St	Interior	Window		Wood	Intact
34	0	mg/cm2	Negative	07/18/23	10:30:03	HDHT	6 S Franklin St	Interior	Window		Wood	Intact
35	0.5	mg/cm2	Negative	07/18/23	10:30:31	HDHT	6 S Franklin St	Interior	Window	Casing	Wood	Intact
36	0.6	mg/cm2	Negative	07/18/23	10:30:39	HDHT	6 S Franklin St	Interior	Window	Sill	Wood	Intact



1305 Radford Street
Christiansburg, Virginia 24073
Telephone: (540) 381-7999

Lead Testing for Construction

Montgomery County
6 S Franklin Street
Christiansburg, Virginia

READING	CONCENTRATION	UNITS	RESULTS	DATE	TIME	USER	SITE	ROOM CHOICE	STRUCTURE	MEMBER	SUBSTRATE	CONDITION
37	0.6	mg/cm2	Negative	07/18/23	10:30:49	HDHT	6 S Franklin St	Interior	Room	Wall	Drywall	Intact
38	0.5	mg/cm2	Negative	07/18/23	10:31:01	HDHT	6 S Franklin St	Exterior	Window		Metal	Intact
39	0.3	mg/cm2	Negative	07/18/23	10:31:39	HDHT	6 S Franklin St	Exterior	Window		Metal	Intact
40	0.2	mg/cm2	Negative	07/18/23	10:31:52	HDHT	6 S Franklin St	Exterior	Window		Metal	Intact
41	0	mg/cm2	Negative	07/18/23	10:32:01	HDHT	6 S Franklin St	Exterior	Roof	Parapet	Metal	Intact
42	0	mg/cm2	Negative	07/18/23	10:32:14	HDHT	6 S Franklin St	Exterior	Roof	Parapet	Metal	Intact
43	0.1	mg/cm2	Negative	07/18/23	10:36:06	HDHT	6 S Franklin St	Exterior	Roof	Curb	Metal	Intact
44	0.1	mg/cm2	Negative	07/18/23	10:36:16	HDHT	6 S Franklin St	Exterior	Roof	Curb	Metal	Intact
45	0.2	mg/cm2	Negative	07/18/23	10:52:20	HDHT	6 S Franklin St	Exterior	Roof	Hatch	Metal	Intact
46	7.7	mg/cm2	Positive	07/18/23	10:57:35	HDHT	6 S Franklin St	Exterior	Window		Wood	Deteriorated
47	8.9	mg/cm2	Positive	07/18/23	10:57:54	HDHT	6 S Franklin St	Exterior	Window	Casing	Wood	Deteriorated
48	3.8	mg/cm2	Positive	07/18/23	10:58:54	HDHT	6 S Franklin St	Exterior	Window	Lintel	Metal	Deteriorated
49	0.3	mg/cm2	Negative	07/18/23	10:59:23	HDHT	6 S Franklin St	Exterior	Window	Cover	Metal	Intact
50	2.1	mg/cm2	Positive	07/18/23	11:20:04	HDHT	6 S Franklin St	Exterior	Window		Wood	Deteriorated
51	5.1	mg/cm2	Positive	07/18/23	11:20:16	HDHT	6 S Franklin St	Exterior	Door	Casing	Wood	Deteriorated
50	0.2	mg/cm2	Negative	07/18/23	11:20:26	HDHT	6 S Franklin St	Exterior	Door		Metal	Intact
51	10.4	mg/cm2	Positive	07/18/23	11:20:40	HDHT	6 S Franklin St	Exterior	Porch	Column	Plaster	Deteriorated
52	0	mg/cm2	Negative	07/18/23	11:21:09	HDHT	6 S Franklin St	Calibration				
53	1	mg/cm2	Positive	07/18/23	11:21:20	HDHT	6 S Franklin St	Calibration				

Photos

6 S Franklin Street



Pipe insulation was found to be asbestos containing by the laboratory. THIS MATERIAL IS FRIABLE. THIS MATERIAL IS DAMAGED.

6 S Franklin Street



Asphaltic Roof Remnants were found to be asbestos containing by the laboratory.

6 S Franklin Street

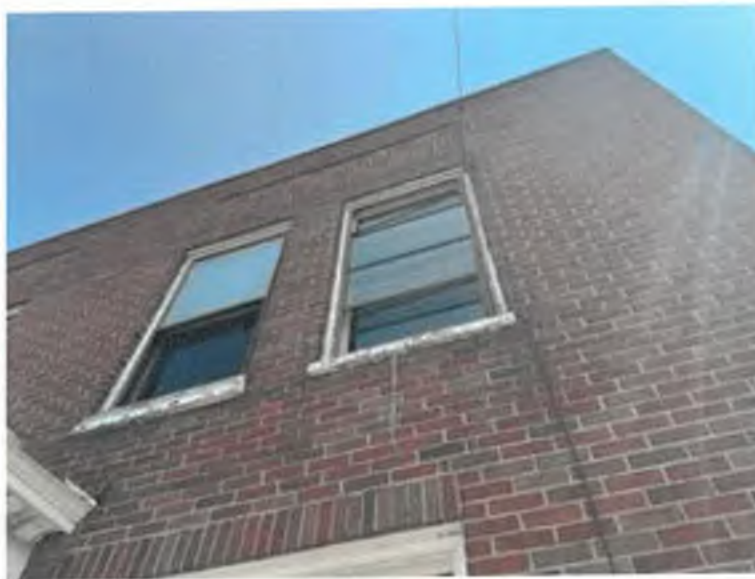


Window Framing Caulk on Original Wooden Framed Windows was found to be asbestos containing by the laboratory.



ALL Exterior Components and Surfaces Painted White were found to utilize lead-based paint.

6 S Franklin Street



ALL Exterior Components and Surfaces Painted White were found to utilize lead-based paint.

6 S Franklin Street



ALL Exterior Components and Surfaces Painted White were found to utilize lead-based paint.

6 S Franklin Street



Yellow Wall Tile in Restroom was identified as a lead component.

Applicable Licenses

COMMONWEALTH of VIRGINIA

Department of Professional and Occupational Regulation
9960 Mayland Drive, Suite 400, Richmond, VA 23233
Telephone: (804) 367-8500

EXPIRES ON
12-31-2023

NUMBER
3303004480

BOARD FOR ASBESTOS, LEAD, AND HOME INSPECTORS
ASBESTOS INSPECTOR LICENSE



JARED ALLEN CROWDER
5789 TABERNACLE PL
PULASKI, VA 24301



[Signature]
Executive J. Keith Bricker

Status can be verified at <http://www.dpor.virginia.gov>

(SEE REVERSE SIDE FOR PRIVILEGES AND INSTRUCTIONS)

DPO-LIC (02/2017)

COMMONWEALTH of VIRGINIA

Department of Professional and Occupational Regulation
9961 Mayland Drive, Suite 400, Richmond, VA 23233
Telephone: (804) 367-8500

EXPIRES ON
02-29-2024

NUMBER
3355001118

BOARD FOR ASBESTOS, LEAD, AND HOME INSPECTORS
LEAD INSPECTOR LICENSE



JARED ALLEN CROWDER
5789 TABERNACLE PL
PULASKI, VA 24301



Dan J. Hays
Director

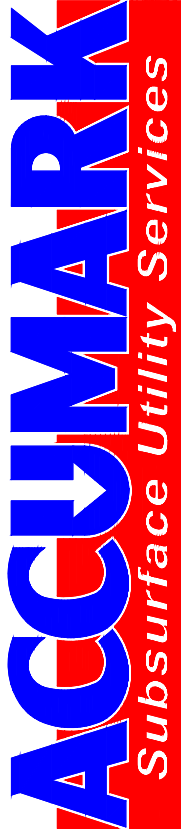
Status can be verified at <http://www.dpor.virginia.gov>

DPOR-LIC (02/2017)

(SEE REVERSE SIDE FOR PRIVILEGES AND INSTRUCTIONS)

APPENDIX C

Duct Bank - Test Hole Inventory Report



Proud - Professional - Precise

TEST HOLE INVENTORY REPORT - QUALITY LEVEL "A"

Virginia Tech, Montgomery County, VA

Hurt & Proffitt

Date	TH #	Utility Requested	Utility Found	Existing Grade Depth	Material Type	Utility Elevation	Pavement Thickness	Utility Owner
08/01/23	1	Electric	(4) 4" Electric	A 3.10	Plastic	2096.82	0.4' Asphalt	AEP
08/01/23	2	Fiber Optic	4" Fiber Optic	A 2.26	Plastic	2097.61	0.4' Asphalt	VZN
07/31/23	3	Electric	Electric Duct Bank	A 0.76	Concrete	2095.54	0.4' Asphalt	AEP
07/31/23	3A	Electric	Electric Duct Bank	A 0.72	Concrete	2095.66	0.4' Asphalt	AEP
07/31/23	4	Fiber Optic	(4) 4" Fiber Optic	A 2.97	Plastic	2093.21	0.4' Asphalt	VZN
07/31/23	5	Electric	Electric Duct Bank	A 1.05	Concrete	2093.54	N/A	AEP
07/31/23	6	Fiber Optic	(4) 4" Fiber Optic	A 2.33	Plastic	2092.19	N/A	VZN

Hurt & Proffitt - Point of Contact: Christopher Kaknis (540) 552-5592

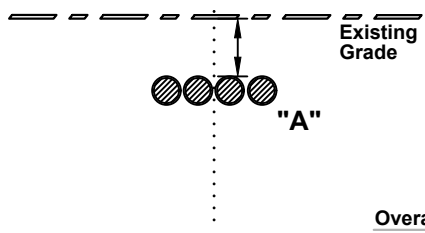
AccuMark - Point of Contact: James Brooks (804) 432-5832

ACCUMARK

Subsurface Utility Services

Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

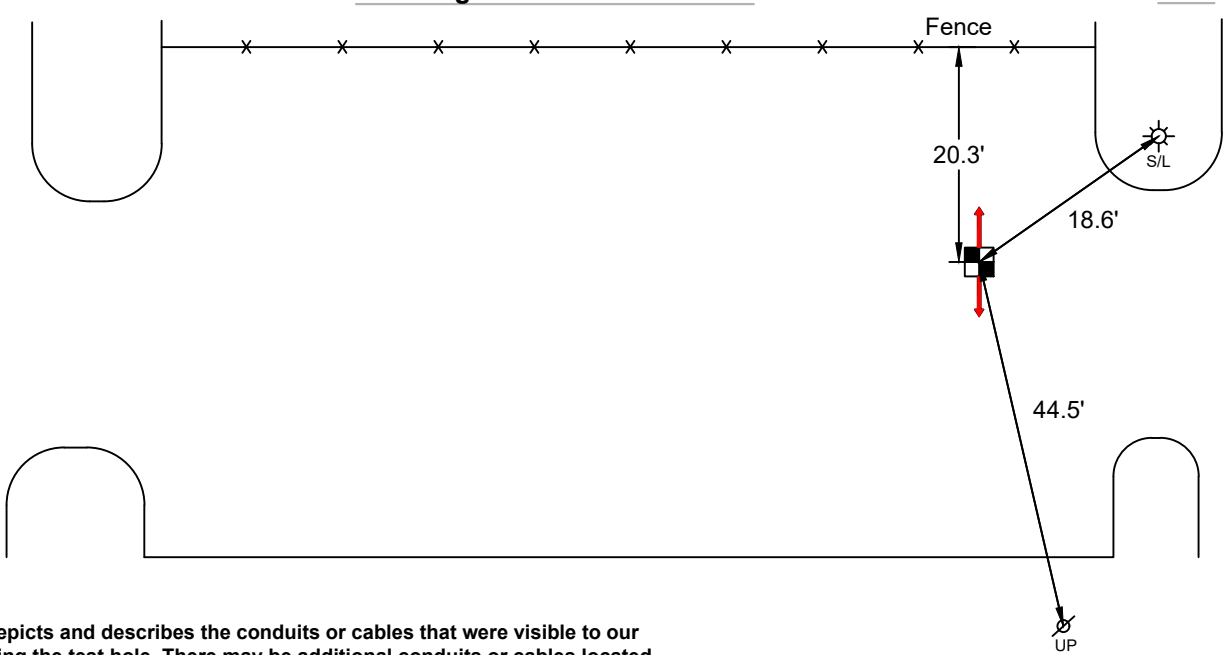
Test Hole #:	1	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank Hurt & Proffitt Blacksburg, VA	Test Hole Date:	08/01/23
Point of Contact:	Christopher Kaknis (540) 552-5592	Project Location:	Christiansburg Montgomery County, VA
Utility Requested:	Electric	Soil Conditions:	Clay, Dry, Hard
		Pavement Condition:	Good 0.4' Asphalt

Test Hole Cross Section 		Elevation / Survey Information: Located By: Accumark, Inc. Vertical Datum: NAVD88 Benchmarks Used: BM#1 Elev: N/A Description: N/A BM#2 Elev: N/A Description: N/A Test Hole Reference Mark Northing: 3576286.45 Easting: 10926831.46 Elevation: 2099.92	
Drawn Facing:	Northwest	Overall Utility Width:	18.0" +/-

General Notes:
Target utility found. PK set over the center of the utility configuration.

Exposed Utility Information									
Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Electric	(4) 4"	Plastic	3.10	2096.82	N/A	N/A	AEP	Good

Site Diagram / Location Details: Scale: (NTS)



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.

#411-1035

ACCUMARK

Subsurface Utility Services

Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>1</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



DWH 08/14/23

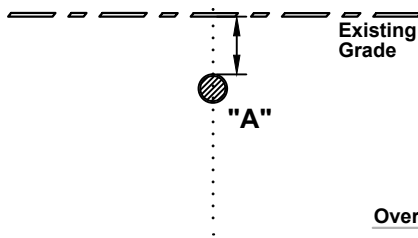
ACCUMARK

Subsurface Utility Services

Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

Test Hole #:	2	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank	Test Hole Date:	08/01/23
	Hurt & Proffitt	Project Location:	Christiansburg
	Blacksburg, VA		Montgomery County, VA
Point of Contact:	Christopher Kaknis	Soil Conditions:	Clay, Dry, Hard
	(540) 552-5592	Pavement Condition:	Good 0.4' Asphalt
Utility Requested:	Fiber Optic		

Test Hole Cross Section



Drawn Facing:
Northwest

Overall Utility Width:
4.5" +/-

Elevation / Survey Information:

Located By:	Vertical Datum
Accumark, Inc.	NAVD88
Benchmarks Used:	
BM#1 Elev: N/A	Description: N/A
BM#2 Elev: N/A	Description: N/A
Test Hole Reference Mark	
Northing: 3576288.48	Easting: 10926833.50
	Elevation: 2099.87

General Notes:

Target utility found. PK set over the crown of the target utility.

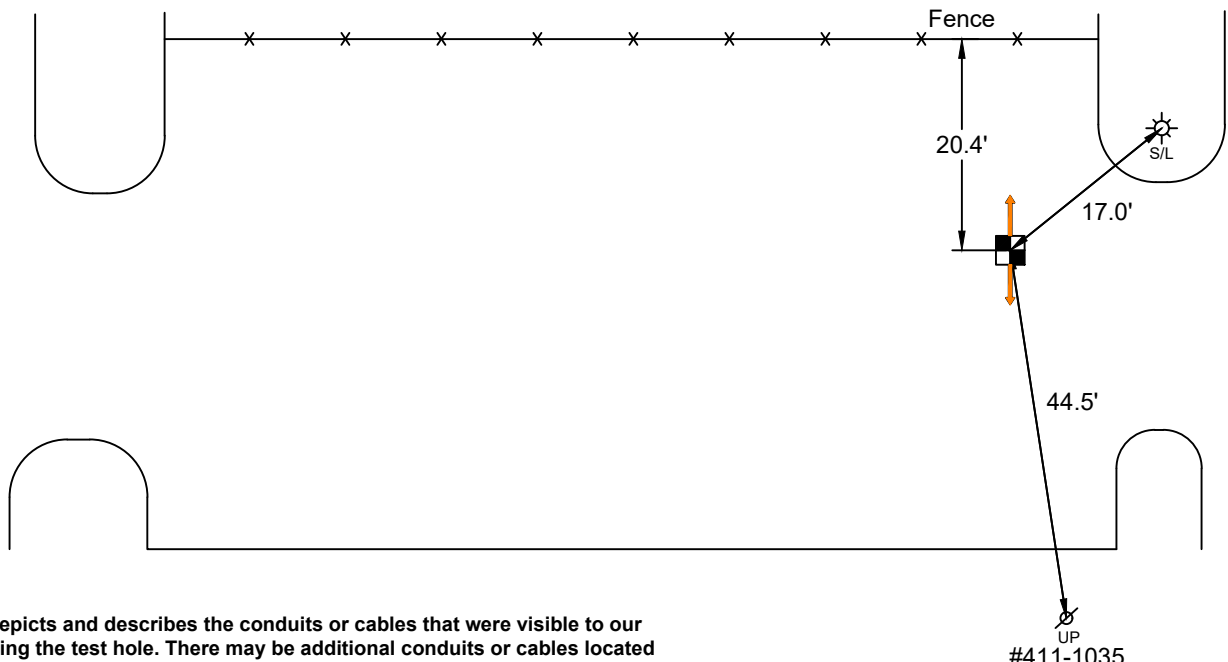
Exposed Utility Information

Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Fiber Optic	4"	Plastic	2.26	2097.61	N/A	N/A	VZN	Good



Site Diagram / Location Details:

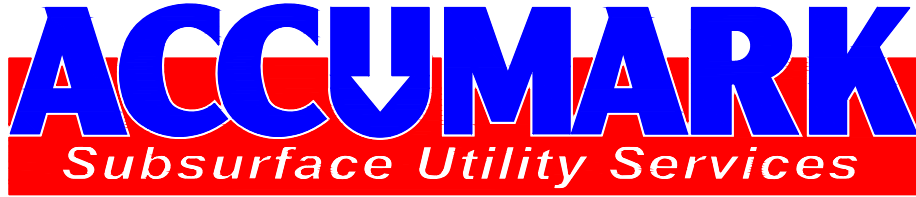
Scale: (NTS)



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.

#411-1035

DWH 08/08/23



Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>2</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



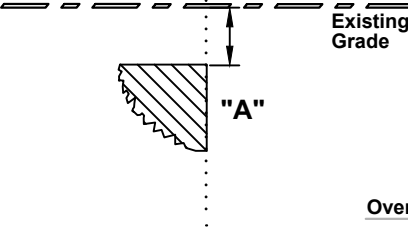
DWH 08/14/23

ACCUMARK

Subsurface Utility Services

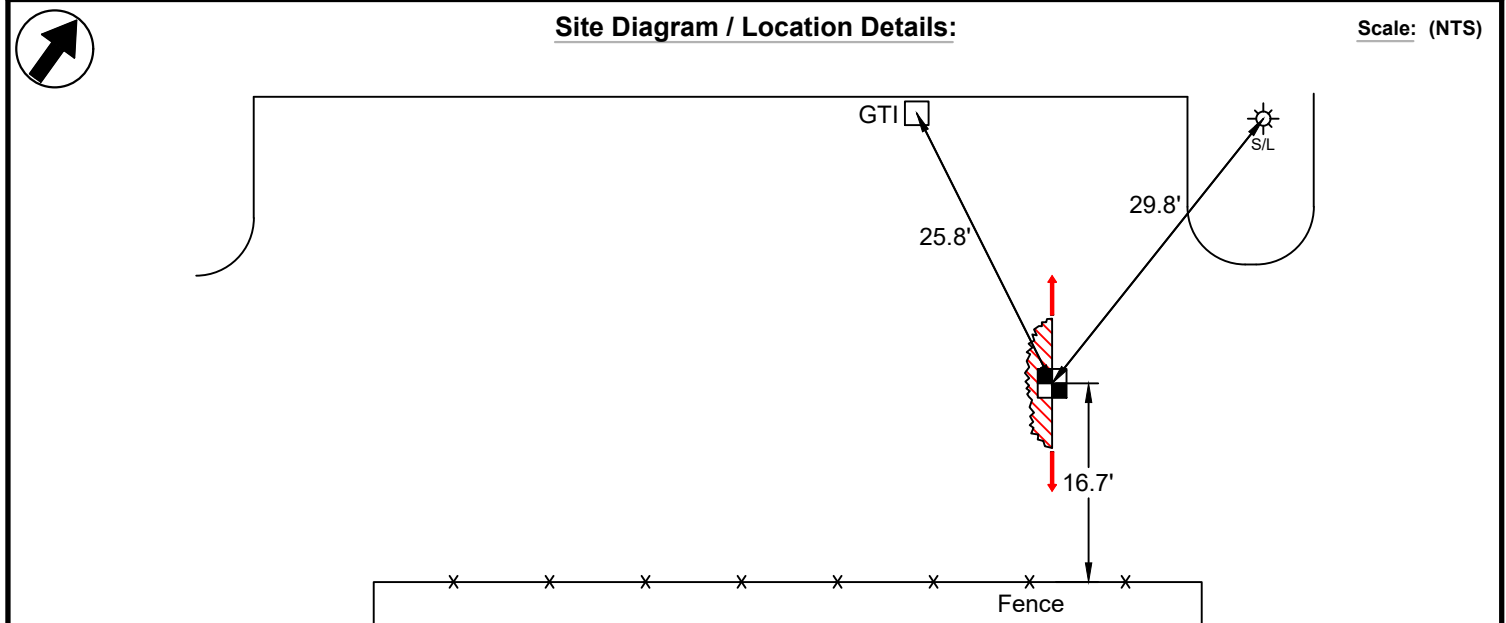
Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

Test Hole #:	3	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank	Test Hole Date:	07/31/23
	Hurt & Proffitt	Project Location:	Christiansburg
	Blacksburg, VA		Montgomery County, VA
Point of Contact:	Christopher Kaknis	Soil Conditions:	Clay, Dry, Soft
	(540) 552-5592	Pavement Condition:	Good 0.4' Asphalt
Utility Requested:	Electric		

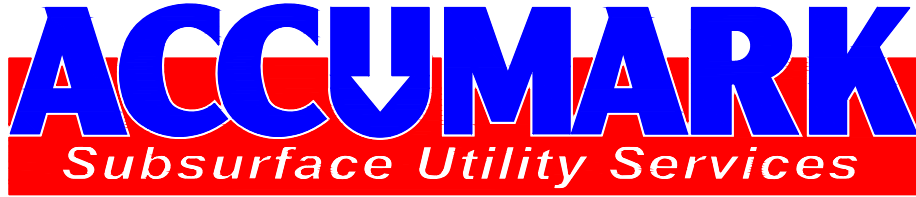
Test Hole Cross Section		Elevation / Survey Information:	
		Located By: <u>Accumark, Inc.</u> Vertical Datum: <u>NAVD88</u> Benchmarks Used: BM#1 Elev: <u>N/A</u> Description: <u>N/A</u> BM#2 Elev: <u>N/A</u> Description: <u>N/A</u> Test Hole Reference Mark Northing: <u>3576322.99</u> Easting: <u>10926790.75</u> Elevation: <u>2096.30</u>	
Drawn Facing:	Overall Utility Width:		
Northwest	See Note		

General Notes:
Target utility found. PK set over the northeast edge of the duct bank. Total width of the duct bank is 30.0". The other edge of the duct bank can be found in TH 3A.

Exposed Utility Information									
Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Electric Duct Bank	See Note	Concrete	0.76	2095.54	2.09	2094.21	AEP	Good



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.



Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>3</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



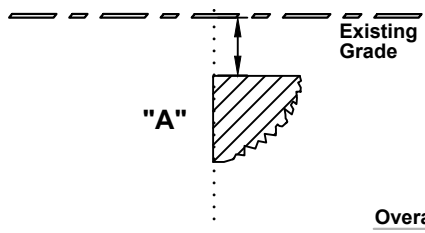
DWH 08/14/23

ACCUMARK

Subsurface Utility Services

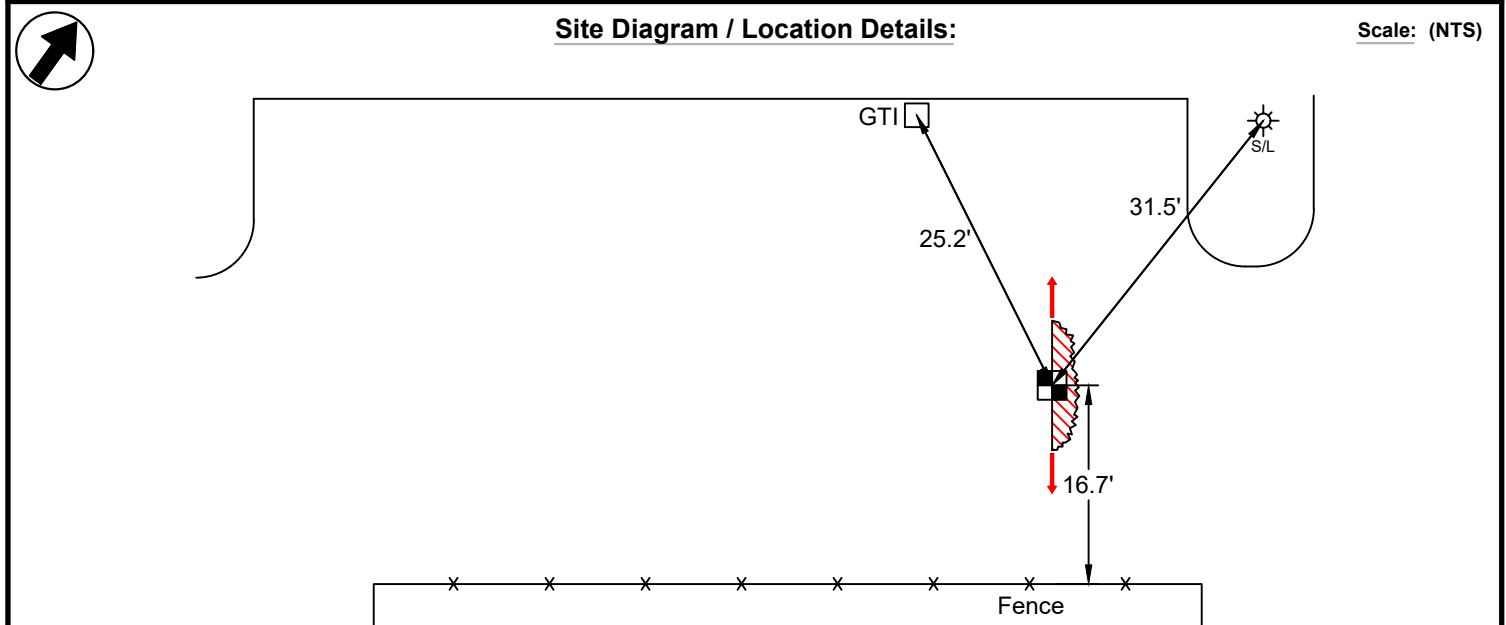
Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

Test Hole #:	3A	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank	Test Hole Date:	07/31/23
	Hurt & Proffitt	Project Location:	Christiansburg
	Blacksburg, VA		Montgomery County, VA
Point of Contact:	Christopher Kaknis	Soil Conditions:	Clay, Dry, Soft
	(540) 552-5592	Pavement Condition:	Good 0.4' Asphalt
Utility Requested:	Electric		

Test Hole Cross Section 		Elevation / Survey Information: Located By: Accumark, Inc. Vertical Datum: NAVD88 Benchmarks Used: BM#1 Elev: N/A Description: N/A BM#2 Elev: N/A Description: N/A Test Hole Reference Mark Northing: 3576321.14 Easting: 10926789.01 Elevation: 2096.38	
Drawn Facing:	Overall Utility Width:		
Northwest	See Note		

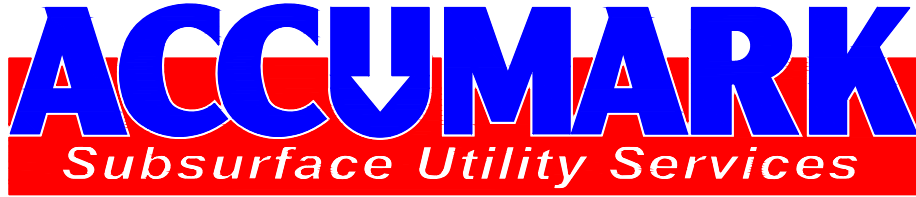
General Notes:
Target utility found. PK set over the southwest edge of the duct bank. Total width of the duct bank is 30.0". The other edge of the duct bank can be found in TH 3.

Exposed Utility Information									
Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Electric Duct Bank	See Note	Concrete	0.72	2095.66	N/A	N/A	AEP	Good



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.

DWH 08/08/23



Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>3A</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



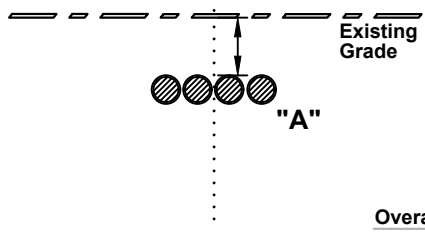
DWH 08/14/23

ACCUMARK

Subsurface Utility Services

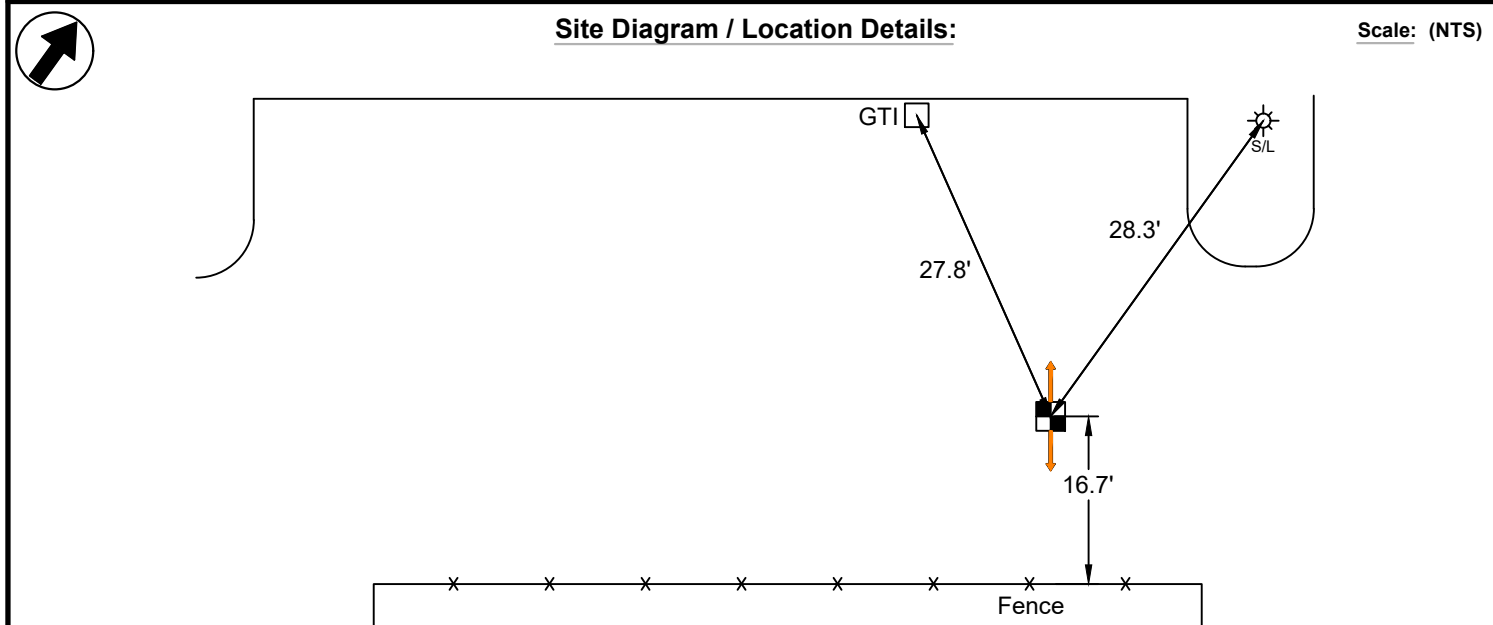
Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

Test Hole #:	4	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank	Test Hole Date:	07/31/23
	Hurt & Proffitt	Project Location:	Christiansburg
	Blacksburg, VA		Montgomery County, VA
Point of Contact:	Christopher Kaknis	Soil Conditions:	Clay, Dry, Hard
	(540) 552-5592	Pavement Condition:	Good 0.4' Asphalt
Utility Requested:	Fiber Optic		

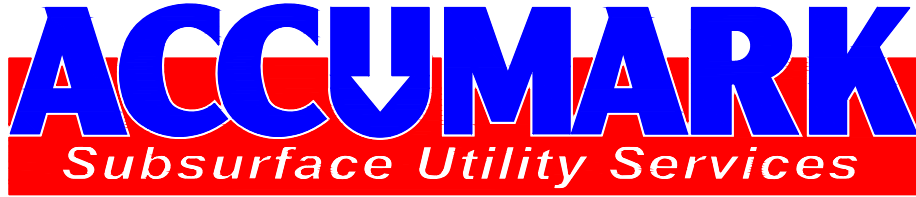
Test Hole Cross Section 		Elevation / Survey Information: Located By: Accumark, Inc. Vertical Datum: NAVD88 Benchmarks Used: BM#1 Elev: N/A Description: N/A BM#2 Elev: N/A Description: N/A Test Hole Reference Mark Northing: 3576325.95 Easting: 10926794.59 Elevation: 2096.18	
Drawn Facing:	Overall Utility Width:		
Northwest	18.0" +/-		

General Notes:
Target utility found. PK set over the center of the utility configuration.

Exposed Utility Information									
Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Fiber Optic	(4) 4"	Plastic	2.97	2093.21	N/A	N/A	VZN	Good



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.



Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>4</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



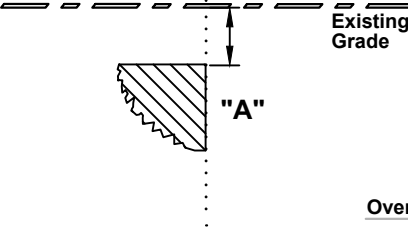
DWH 08/14/23

ACCUMARK

Subsurface Utility Services

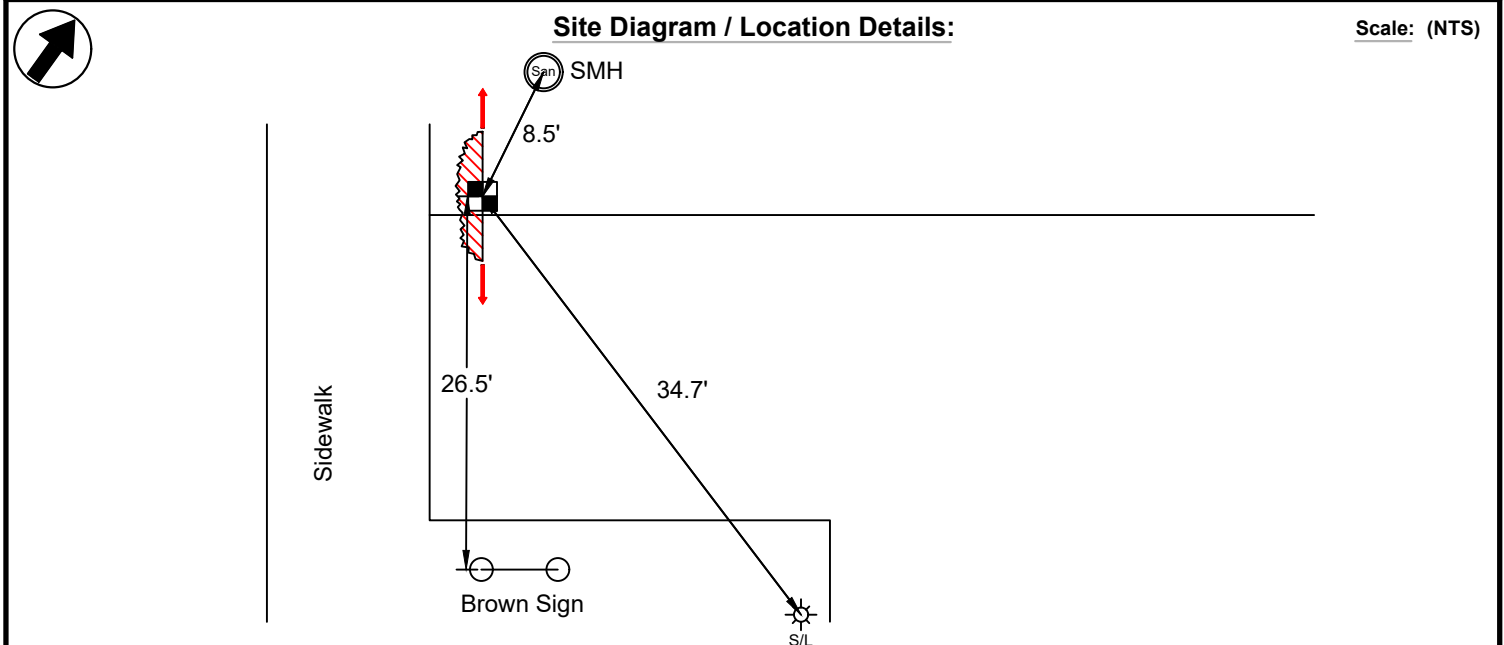
Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

Test Hole #:	5	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank	Test Hole Date:	07/31/23
	Hurt & Proffitt	Project Location:	Christiansburg
	Blacksburg, VA		Montgomery County, VA
Point of Contact:	Christopher Kaknis	Soil Conditions:	Clay, Dry, Hard
	(540) 552-5592	Pavement Condition:	N/A
Utility Requested:	Electric		N/A

Test Hole Cross Section		Elevation / Survey Information:	
		Located By: <u>Accumark, Inc.</u> Vertical Datum: <u>NAVD88</u> Benchmarks Used: BM#1 Elev: <u>N/A</u> Description: <u>N/A</u> BM#2 Elev: <u>N/A</u> Description: <u>N/A</u> Test Hole Reference Mark Northing: <u>3576364.70</u> Easting: <u>10926751.02</u> Elevation: <u>2094.59</u>	
Drawn Facing:	Overall Utility Width:		
Northwest	See Note		

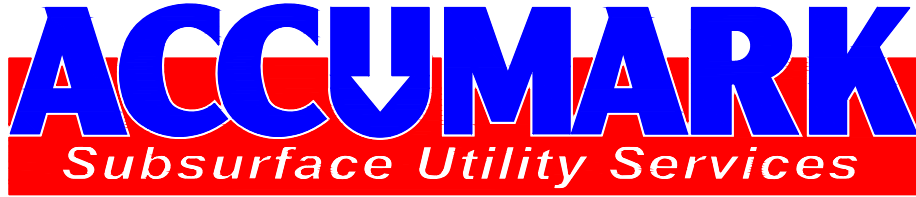
General Notes:
Target utility found. Chiseled "X" set over the northeast edge of the duct bank. Unable to obtain total width because southwest edge is under the sidewalk.

Exposed Utility Information									
Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Electric Duct Bank	See Note	Concrete	1.05	2093.54	2.05	2092.54	AEP	Good



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.

DWH 08/08/23



Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>5</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



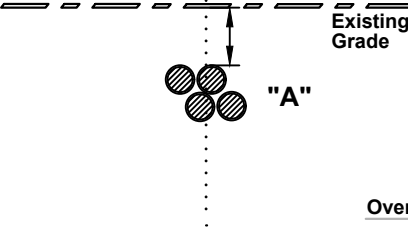
DWH 08/14/23

ACCUMARK

Subsurface Utility Services

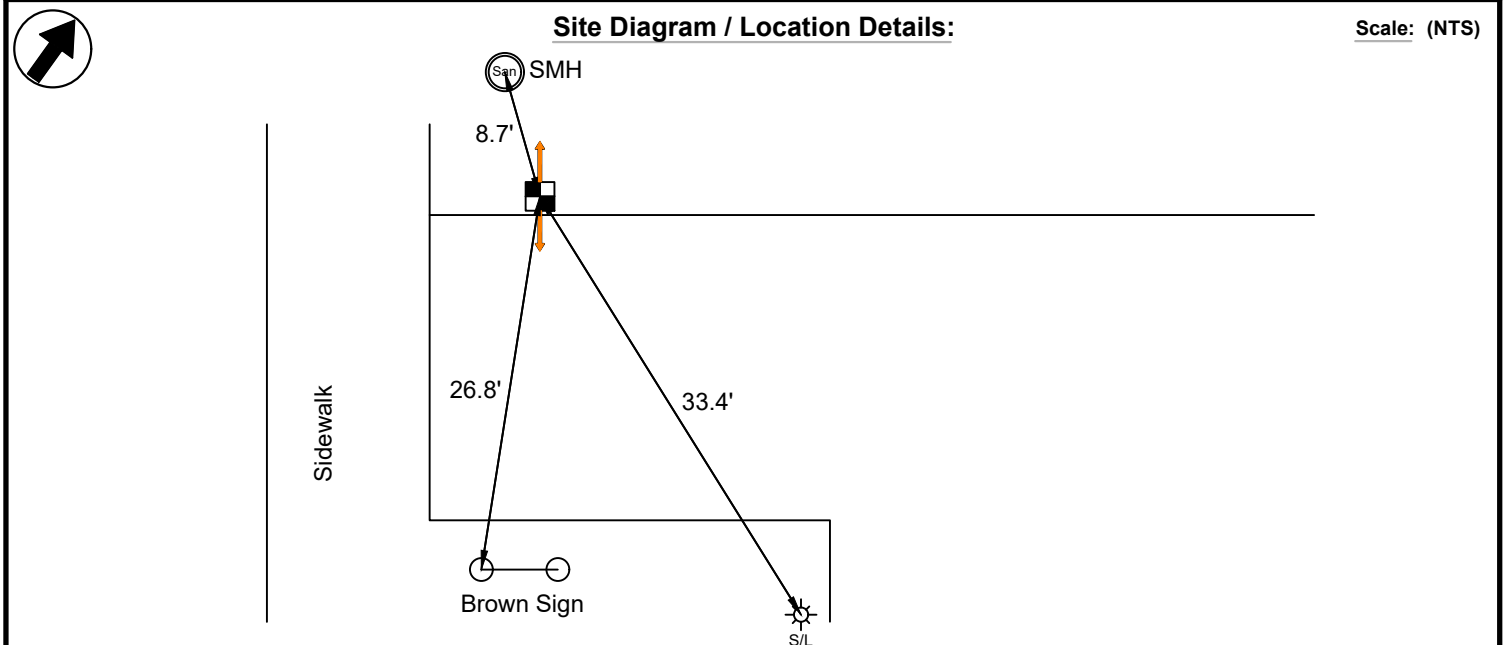
Proud - Professional - Precise
Utility Test Hole Report - Quality Level "A"

Test Hole #:	6	Accumark Job#:	23-405
Project Name:	Virginia Tech	Client Reference#:	N/A
Requested By:	MACS Duct Bank	Test Hole Date:	07/31/23
	Hurt & Proffitt	Project Location:	Christiansburg
	Blacksburg, VA		Montgomery County, VA
Point of Contact:	Christopher Kaknis	Soil Conditions:	Clay, Dry, Soft
	(540) 552-5592	Pavement Condition:	N/A
Utility Requested:	Fiber Optic		N/A

Test Hole Cross Section		Elevation / Survey Information:	
		Located By:	Vertical Datum
Drawn Facing:		Accumark, Inc.	NAVD88
Northwest		Benchmarks Used:	
		BM#1 Elev: N/A	Description: N/A
		BM#2 Elev: N/A	Description: N/A
		Test Hole Reference Mark	
		Northing:	Easting:
		3576368.24	10926754.53
			Elevation:
			2094.52

General Notes:
Target utility found. Chiseled "X" set over the center of the utility configuration.

Exposed Utility Information									
Utility	Utility Found	Utility Size	Material Type	Depth @ Top of Utility	Elevation @ Top	Duct Bank		Utility Owner	Condition
						Bottom Depth	Elevation		
A	Fiber Optic	(4) 4"	Plastic	2.33	2092.19	N/A	N/A	VZN	Good



Note: This report depicts and describes the conduits or cables that were visible to our crew upon excavating the test hole. There may be additional conduits or cables located below this configuration which were not visible to the test hole crew.

Proud • Professional • Precise

Utility Test Hole Report - Quality Level "A"

Test Hole #:	<u>6</u>	Project Numbers:	<u>23-405</u>
Project Name:	<u>Virginia Tech - MACS Duct Bank</u>		
Client:	<u>Hurt & Proffitt</u>	Project Location:	<u>Blacksburg, Virginia</u>



DWH 08/14/23